ECOLOGY AND BEHAVIOUR OF INDIAN GREY WOLF (*Canis lupus pallipes* Sykes, 1831) IN THE DECCAN GRASSLANDS OF SOLAPUR, MAHARASHTRA

SUMMARY

Thesis submitted for the Degree of
Doctor of Philosophy

IN
WILDLIFE SCIENCE

BY
SATISH KUMAR

CENTRE OF WILDLIFE & ORNITHOLOGY
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)
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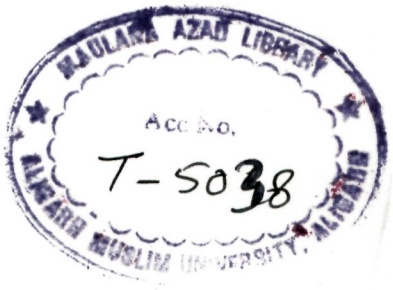
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During the first two decades of independence, the Blackbuck which was abundant all over the Indian plains but especially in the Deccan, was hunted out in most of its range. However, since the enactment of Wildlife (Protection) Act of 1972, there has been resurgence of Blackbuck populations in certain areas such as Nannaj. The Blackbuck being a major natural prey of the wolf, the latter has also increased or stabilized in some areas. However, wolf is a regular predator of livestock, which

brings it in direct conflict with humans which needs special emphasis. This study was focused on the following objectives:

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Open width Transects in different habitats were monitored to find out the abundance of Blackbuck which is the major prey species of wolf at the study site. Simultaneous counts were made for two consecutive days from 07:00 to 08:30 H on 15 July every year. The pack was not radio-collared, the individual wolves were recognized by natural marks.

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interference. Such areas were later investigated for habitat characteristics.

The Nannaj Pack was monitored on an intensive, regular basis from July 1991 to August 1994. This wolf pack was usually spotted at a kill between 06:00-07:00 H. With the passage of time and experience, it was not difficult to locate the pack on kills. Once the pack was spotted at a kill, a continuous attention was paid to it until the pack members moved away from the kill. Data was collected on sex and age of the kill, biomass left unconsumed and distance of the kill from the protected area where the animal was supposedly killed. The terrain and the vegetation of the site were also recorded. Similarly for domestic ungulates (goats and sheep), data on age, sex, location and distance of the kill from the protected area of the Sanctuary were recorded.

The weight of each kill left unconsumed and the number of wolves that were known to have fed on the kill with certainty were recorded to compute the mean consumption rate of wolves.

Pups refer to the individuals less than six months of age, subadults or juveniles as 6-7 months old individuals, yearlings as 1-2 years and adults two and more than two years of age. However, it is extremely difficult to distinguish yearlings from adults in the field unless they are observed from very close quarters.

The breeding period (December-August) includes denning and post-denning

periods (during which the pups are reared till they start hunting on their own). Dens were located by keeping regular notice on the movement of the pack during December to January. Once a den or rendezvous site was located, care was taken not to disturb wolves by not going close to them at these sensitive sites. After an active den was located, hide was placed at about 300 m distance from it for observing them at dens.

Results

The total count of Blackbuck population in Nannaj area was found to be around 700 which keeps fluctuating year-to-year depending on precipitation in the area and hunting pressures on the population. A part of the population is also removed by wolves and stray dogs round the year.

The contribution of the adult females to the total population was highest followed by the sub-adult females (about 20%) while the adult males (M1 and M2) comprised 7.7% of the population in 1991. In 1992, again adult females constituted the highest population (68 %).

The sex ratio of Blackbuck was found to be disproportional and highly biased towards females. The factors for mortality other than natural death are natural predators such as the Indian wolf and stray dogs. It was found that M1 and M2 males and fawns are more prone to predation by wolves than any other age and sex class of the Blackbuck.

The maximum concentration of Blackbuck was always seen in and around the grassland Site-1 mainly because of less disturbance in this area. Thirty nine percent of the total Blackbuck kills were located at this site.

The grassland had highest Blackbuck density among all the habitats during all seasons except summer when it is less or nearly the same as in the woodlots.

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Large herds were sighted in open areas whereas smaller groups in the plantation which may have been evolved as an anti-predator strategy. Smaller groups may be able to remain undetected in the plantation cover. On the other hand, in an open grassland, the probability of spotting a predator by a large herd and thus becoming alert for self-defence is more than in the area with more vegetative cover. Nevertheless, wolves manage to locate sick individuals from large herds too and chase them off from the herds.

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minimum population of 53 and maximum of 85 wolves. Much of the range is inhabited by low pack-sizes. The largest pack-size comprised of 12 wolves and smallest of two individuals. This is because of the high human populations in such areas and disturbance. Moreover, the natural prey base and livestock (goats and sheep) are also low in these areas.

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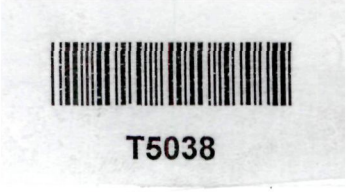
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CERTIFICATE

This is to certify that the thesis **"Ecology and behaviour of the Indian Grey Wolf (*Canis lupus pallipes*) in the Deccan grasslands of Solapur, Maharashtra"** embodies the original work of Mr. Satish Kumar. The thesis submitted for the award of Ph.D. degree in Wildlife Science, of Aligarh Muslim University, Aligarh by the candidate is worthy of consideration for the award. This work has been done by the candidate under my supervision.

12th February 1998

Asad R. Rahmani
Supervisor

Telephone-Office: 401052

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ACKNOWLEDGEMENTS

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CHAPTER ONE

GENERAL INTRODUCTION

India is among the "megadiversity" countries of the world. This is due to great biogeographic variability which arises from variation in soil, topography and rainfall. Rodgers and Panwar (1988) and Meher-Homji (1990) have given biogeographical classification of the country into several distinct zones, biotic provinces and biomes.

Mammalian fauna of India is diverse with respect to carnivores. Although India forms only 2.2% of the land area of the world, it harbours 55 (24%) out of 231 extant carnivore species (Johnsingh 1986). Among these carnivores, there are six large predators which live primarily by hunting large prey such as ungulates and primates. These large predators comprise Asiatic lion *Panthera leo persica*, Tiger *Panthera tigris tigris*, Leopard *Panthera pardus*, Snow leopard *Panthera uncia*, Wolf *Canis lupus*, Wild dog *Cuon alpinus* and Striped hyena *Hyaena hyaena.* Different biogeographic zones have distinct mammalian assemblages, each harbouring a characteristic community of large predators and their prey species. The ungulate species found in the wolf areas in the plains of semi-arid zone are Blackbuck *Antilope cervicapra*, Chinkara *Gazella benneti*, Nilgai *Tragocamelus boselaphus* and Wild boar *Sus scrofa*.

The canidae as a family of carnivores has been remarkably successful in colonizing most of the land area of the earth, with some 14 living genera and about 35

species. Its representatives have a worldwide distribution thriving on every continent except Antarctica and Australia (Dingo *Canis familiaris dingo* was introduced by man). Canids occupy diverse ecological niches with some species functioning basically as hunters and others as scavengers. Several lead a solitary life whereas a few are social (e.g., African Wild Dog *Lyacon pictus*, Wolf, Dhole. Wolf is one of the largest members of the dog family. It is an expert hunter and preys chiefly on large hoofed animals. Fennecs or Fennec foxes *Fennecus zerda* are the smallest members (about 1.5 kg) of the family canidae.

There are two types of grey wolves in North America: the Timber wolf and the Tundra wolf. The Timber wolf lives in wooded, subarctic regions. The Tundra wolf, on the other hand, makes its home on the treeless plains of the Arctic. There is a separate species of wolves called Red wolf *Canis rufus* found in Louisiana and Texas and is nearly extinct. The taxonomic position of the Red wolf is still unclear since it is regarded as a hybrid between the Grey Wolf and the Coyote *Canis latrans*.

Thirty-two subspecies of Grey Wolf are recognized in the world (Mech 1970) out of which eight are found in Eurasia.

This highly intelligent, apex predator (in many diverse natural ecosystems) can live in almost any kind of climate, except dense tropical forests. In ancient times they roamed throughout the northern half of the world, but wherever large number of

people settled, they destroyed wolves. As a result, these animals have disappeared from many areas of their former range. Today wolves survive in sparsely populated northern regions, such as Alaska, Minnesota, Canada (most of northern America), China, Mongolia and Russia. Small numbers of wolves still inhabit wilderness of Mexico, Norway, Spain, Italy, Yugoslavia, Romania, Greece, southern Afghanistan, Pakistan, the Middle East (Israel, Syria, southern Iraq, southern Iran and Kuwait), India and Nepal.

Wolves are making their way in some countries now from where they had been extirpated many years back, e.g., Germany and France. In Japan, the World Conservation Union (I.U.C.N.) has suggested to reintroduce them into their former range from where they became extinct in mid forties of the present century. In Europe some bodies such as I.U.C.N. and European Wolf Network are lobbying for wolf recovery. The U.S. Fish and Wildlife Service has started its Mexican gray wolf (*Canis lupus baileyi*) reintroduction programme in southwestern United States (New Mexico and Arizona).

Today the plight of all the large predators in India is critical with the burgeoning trend of human population. Several species such as the Wild ass *Equus hemionus* and the Asiatic lion have declined drastically in the last few decades and have been reduced to remnant populations. There are no sound management and conservation plans for most of the large predators except for the Tiger and the Asiatic lion. The Indian wolf is a victim of such circumstances existing in India. The

major causal factors for such a situation of these large carnivores in general and the Indian Wolf in particular are: the decline in prey base, loss of habitat and illegal shooting and trapping. Despite the wildlife legislations and acts, the overall situation of all large carnivores is grave.

There are two subspecies of wolf in India: the Indian Grey Wolf *Canis lupus pallipes* in the plains, and the Tibetan Wolf *C. l. chanco* (=*laniger*) in the Trans-Himalayas (Ladakh, Lahaul Spiti, Kinnaur and Sikkim) and Himalayas (Sikkim) from 3,000 to 4,000 metres. Both are classified as endangered under the Indian Wildlife (Protection) Act, 1972.

The Indian Grey Wolf is one of the smallest wolves of the world. This subspecies represents the southern most limit of the range of wolf distribution in the world. The distribution range of the *Canis lupus pallipes* extends from Israel, Syria, southern Iraq, southern Iran, Kuwait in the Middle East to southern Afghanistan and Pakistan to India. However, the taxonomic position of the wolves in Syria is not well established (Mendelssohn 1983a).

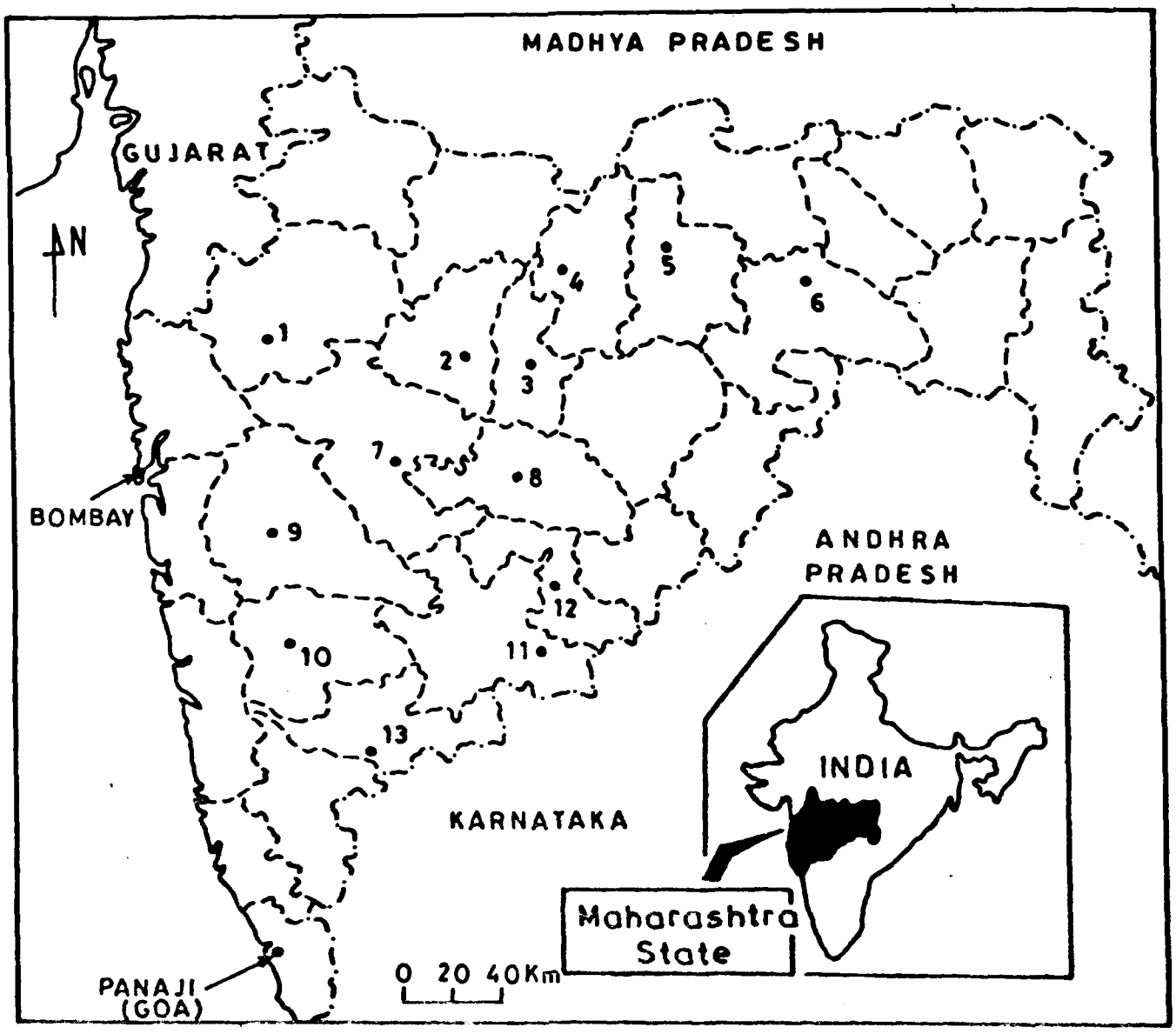
Habitat and wild prey of these species vary markedly. The Indian Grey Wolf (henceforth called as the Indian Wolf) lives in smaller packs, usually 4-7 individuals. It is uncommon and found in open grasslands, shrublands, and rocky hills of central, western, and peninsular India, in isolated pockets of the states of Rajasthan, Bihar, Madhya Pradesh, Gujarat, Maharashtra, Karnataka and Andhra Pradesh. Presently

there are only two wolf reserves in India: one in Bihar (Mahuadhar Wolf Sanctuary) and the other in Karnataka (Melekote Wolf Sanctuary). Recently there have been reports of wolves from north India in Uttar Pradesh. Its habitat in this state has been taken over by intensive agriculture and the natural prey is adversely affected.

In Maharashtra the wolf is distributed in small pockets of semi-arid areas comprising Nasik, Aurangabad, Jalna, Buldana, Akola, Yavatmal, Ahmednagar, Beed, Pune, Satara, Solapur, Jalgaon, Osmanabad and Sangli (Fig. 1.1)

Unlike its temperate cousin, the habitat of wolf in India is semi-arid dry grasslands, scrublands, grazing land and rocky low hills. The grazing lands lie mainly in the marginal agricultural areas. There is a tremendous livestock pressure on these areas which to some extent contributes to the decline of wolf's prey.

We have very little information on the food habits, hunting behaviour, ranging and social behaviour of the Indian wolf. Out of 55 species of predators in India, plight of all the large predators is precarious and all have been placed under the threatened or endangered categories. The smaller predators on the other hand are relatively in a better position although some of them are also included in the endangered species list. The Indian Wolf has been placed in the Convention on International *Trade on Endangered Species (CITES) Appendix II* as vulnerable. The Indian Wildlife (Protection) Act 1972 classifies the Indian Grey Wolf as an endangered species.



Key

1. Nasik 2. Aurangabad 3. Jalna 4. Buldana 5. Akola 6. Yavatmal 7. Ahmednagar 8. Beed 9. Pune 10. Satara 11. Solapur 12. Osmanabad 13. Sangli

Fig. 1.1 The districts of Maharashtra inhabited by the Indian grey wolf

The status of the population is not known in the country. The Tibetan Wolf is fairly common in the Himalayan and Trans-Himalayan ranges of Ladakh (Jammu and Kashmir), Lahaul Spiti and Kinnaur (Himachal Pradesh) and Sikkim. There is little information on this race of the wolf (Fox and Chundawat 1996). The population of this subspecies has been estimated to be around 300 animals, surviving in low density in about 70,000 sq. km of the Indian territory. It is also found in Nepal (Amatya 1997), Afghanistan, Pakistan, Bhutan, China and Mongolia (Mech 1982). But nothing is known on its status in these countries. One of the possible reasons of their existence in low density is the low prey base in these regions.

During the first two decades of India's Independence, the Blackbuck which was abundant all over the Indian plains especially in the Deccan, was hunted out in most of its range. However, since the enactment of the Wildlife (Protection) Act of 1972, there has been resurgence of Blackbuck populations in certain areas (Rahmani 1991). The Blackbuck being a major natural prey of the wolf, its (wolf) number has also increased or stabilized in some areas. The Indian Wolf is unique with regard to the environment in which it lives in comparison to most of the races of wolves. Its conspecifics reported to be more of scavengers than carnivores are attracted to garbage dumps around human settlements in Israel (Mendelssohn 1983a, b) and goats and sheep carcasses in Saudi Arabia (Iyed A. Nader 1992, pers. comm.). This habit is not recorded in the Indian Wolf (see predation on domestic ungulates under discussion).

I conducted ecological and behavioural studies on the Indian Wolf for three years (between June 1991 and September 1994) in an area of 30 Km^2 in the Great Indian Bustard Sanctuary at Nannaj (GIB Sanctuary), Solapur in Maharashtra State. One pack (named **Nannaj Pack**) was followed for the detailed studies. There were two other packs: **Gangewadi Pack** and **Mohol Pack** around the Sanctuary which I could identify. Gangewadi Pack was present 20 km northeast from the centre of the territory of the Nannaj Pack whereas Mohol Pack was 25 km west of the territory of the Nannaj Pack.

The wolf exists discontinuously all over the GIB Sanctuary. The Sanctuary, established for the protection of the Great Indian Bustard *Ardeotis nigriceps*, covers numerous villages, towns, crop fields, grazing lands and some pockets of forest land (Rahmani and Manakadan 1986). Therefore, wolf-human conflicts are common, chiefly because of wolf depredations on livestock. The major natural prey of the Indian Wolf in the GIB sanctuary is Blackbuck and Blacknaped Hare *Lepus nigricollis*. However, the wolf is a regular predator of livestock, which brings it in direct conflict with humans. Livestock species which fall prey to wolves are domestic animals, namely, goats, sheep, and calves of cows and buffaloes, pigs and chicken.

Some studies on livestock depredations by predators have been done. For instance, cattle losses to Coyote, Black bear *Ursus americanus*, Wolf, and Mountain lion *Felis concolor* (Dorrance 1982, Gee 1979), predation losses of domestic sheep to Coyote (Dorrance and Roy 1976), livestock depredations by Wolves (Fritts 1982), wolf-livestock conflicts (Fritts *et al.* 1992). Similar studies in India are lacking.

Estimation of depredation by wolves is essential to implement compensation payments, planning management and long-term conservation of the wolf. My studies on livestock depredations in this part of India is an attempt to answer these questions.

Wolf predation on livestock populations remains a highly complex and hotly debated issue in India and in several areas of its geographical range in the world because of the problem of confirming depredations, irrelevant claims by shepherds, farmers, and ranchers, differences of opinion over depredation, and exaggerations of the facts. While studying ecology of the Indian Wolf in the Great Indian Bustard Sanctuary, Nannaj, I attempted to assess the magnitude of the wolf-man conflict resulting due to livestock depredations.

1.1 Genesis of the study

At the beginning of the project, I had planned to work on the crop raiding behaviour of Blackbuck around Nannaj, but with the passage of about two months, it was possible to locate wolves in the Sanctuary quite frequently and also Blackbuck killed by wolves were seen more often than expected due to its rarity. With the frequent sighting of wolves in the Sanctuary, I got my topic of research changed to the present problem on wolves. This was then continued for three years.

The important reason to select this study of wolf behaviour was partly due to my interest in the life of carnivores and also because of insufficient ecological

information on the wolf in India. The wolf is one of the most neglected species among large carnivores in India. Except for some studies in Velavadar National Park (Jhala 1991, 1993), there is lack of scientific information on its status, food and feeding habits, habitat use, wolf-man conflict arising mainly due to livestock depredation, denning habits and breeding biology in other areas of its range. In this plan of work, I attempted to investigate some of the important behavioural aspects of wolves in the Great Indian Bustard Sanctuary at Nannaj.

1.2 Objectives

The study focused on the following objectives:

1. Population of primary prey species
2. Status and dynamics of wolf population
3. Habitat use and preference
4. Interactions with Blackbuck and livestock
5. Breeding biology and
6. Suggest recommendations to the Sanctuary managers and prepare a conservation and management plan for the wolf- based on findings of this study.

CHAPTER TWO

STUDY AREA

2.1 Historical Background of the Sanctuary and wolves

In the early 1970s', Dharmakumarsinhji conducted some surveys in Maharashtra under a project financed by the World Wide Fund for Nature-India (WWF), and recommended certain areas to be declared as Bustard sanctuaries. However, practically nothing was done for five or six years. In 1979, the State Government of Maharashtra, under section 18 of the Wildlife (Protection) Act of 1972, declared an area of 7818.47 sq. km as a Bustard Sanctuary. This vast area falls under three 'talukas' namely Newasa, Shrigondha and Karjat of Ahmednagar and three talukas namely Mohol, Karmala and Madha of Solapur districts (Rego 1980). In due course of time, on the recommendation of the Bombay Natural History Society (BNHS) in 1985, Nannaj area of North Solapur taluka was included in the Sanctuary and the area of the Sanctuary was increased to 8,496 sq. km (Fig. 2.1). The wolf was a rare animal in the Bustard Sanctuary during the field studies of Endangered Species Project of the BNHS in 1980's in the same area (Ali and Rahmani 1984). The frequency of sighting of wolves was extremely low in the Sanctuary (Asad R. Rahmani 1993, pers. comm.). Most of wolf sightings were either of a single wolf or two. However, after establishment of the Sanctuary and protection to the area, in one decade when the present study on grasslands started, wolves were frequently sighted in the Sanctuary. This was the result of the protection given to the Great Indian Bustard *Ardeotis nigriceps* which has benefitted this endangered predator-prey system also. I started my study in 1991 when the pack had seven

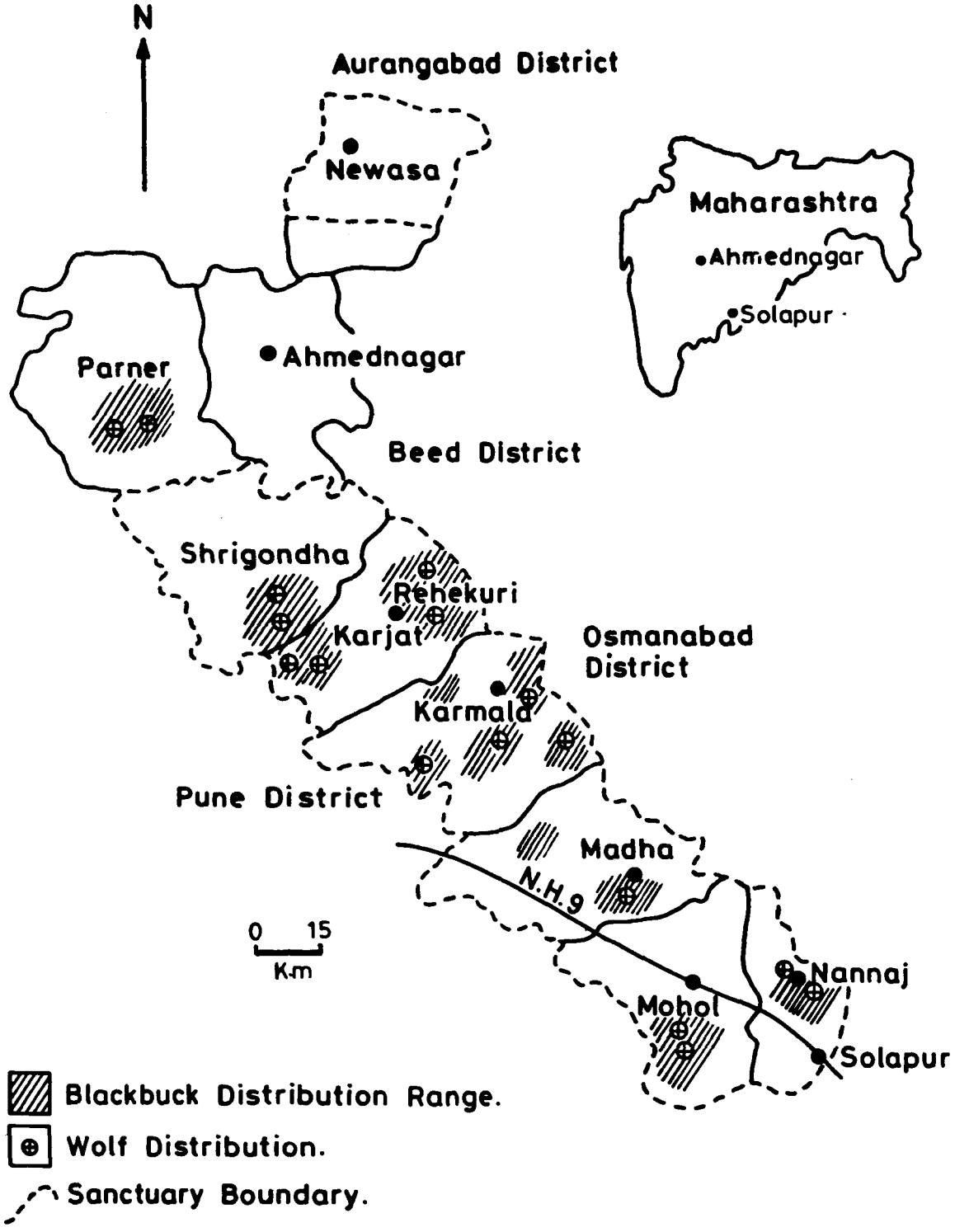


Fig. 2.1 The Bustard Sanctuary of Maharashtra

individuals. The Blackbuck, which is the primary prey species of the Wolf was seen concentrated most of the times in the protected grassland and woodlot plots of the Sanctuary because of lack of disturbance in these plots.

According to Manakadan (1985), no wolves were seen at Nannaj in the year 1981. A pair was first sighted on 6th November 1982. Two more sightings probably of the same pair were recorded in the same year. In 1983 wolf sightings were comparatively more (Table 2.1).

The study on this endangered predator-prey system at this semi-arid part of India was targeted as one of the major objectives of this project on Indian grasslands. The study focussed on the predation on Blackbuck and livestock, habitat use and preference, parent-pup associations and breeding biology.

2.2 Land use Pattern

Rego (1980) has described in detail the land use pattern, livestock numbers and human population of the Bustard Sanctuary complex. The Sanctuary area is heavily populated with 101.29 humans/km^2 while cattle population is 100.12/km^2. In addition to cattle, sheep and goats also constitute the livestock wealth of the area, especially in villages where more than 75 percent of the population lives.

Wherever irrigation facilities are available cultivation is prevalent and cash crops such as Sugarcane (*Saccharum officinarum*) and Rice (*Oryza sativa*) are grown. Under rainfed areas Jawar (*Sorghum bicolor* = *S. vulgare*), Wheat (*Triticum*

Table 2.1* Wolf sightings at Nannaj in the year 1983

Date	Number/Sex	Location
01/08/83	a pair	Grazing lands, east of the Akolakati plot
17/08/83	a pair	Grazing lands, east of the Akolakati plot
19/08/83	a male - limping	Shambhar plot
02/09/83	one - sex (?)	Shambhar plot
06/09/83	a male - limping	Shambhar plot
08/09/83	a male	Mardi I
18/09/83	a male	Shambhar plot
19/09/83	a male - limping	Mardi I
17/10/83	two - sex (?)	Mardi I
06/11/83	two - one with a limp	Shambhar plot

* Taken from Manakadan 1985 (Table : 9, page #109)

aestivum), Maize (*Zea mays*), Pigeon pea (*Cajanus cajan*), Bengal gram or Chick pea (*Cicer arietinum*), Sunflower (*Helianthus annus*) and Cotton (*Gossypium hirsutum*) are the main crops. Under well-irrigation, commercial crops such as Grapes (*Vitis vinifera*), Pomegranate (*Punica granatum*), Lemon (*Citrus limon*) and ber (*Zizyphus mauritiana*) are also cultivated.

Most of the land of the Sanctuary is under dry-land farming, except in Madha taluka of Solapur and Newasa taluka of Ahmednagar districts where canal irrigation facilities are available. Over 90 percent of the land of the Sanctuary is under human habitation, crop fields, grazing lands, settlements, villages and towns.

2.3 Location

Nannaj is a small village 20 km north of Solapur on Solapur-Barshi road, situated between 17° 41'N and 75° 56'E at 486 m elevation (Fig. 2.1). It lies in the drought prone area of the Deccan Plateau which covers an area of about 7,005,000 km². Deccan Plateau lies between Eastern and Western Ghats and south of the line of the Satpura and Hazaribag ranges. The Peninsula is triangular in shape - rising from 500 to 1000m in height, sloping eastwards and westwards.

2.4 Climate

Climate of Solapur is semi-arid. The annual climate cycle includes three seasons: summer (February to mid June), monsoon (mid June to mid October) and winter (mid October to January). Due to the rain shadow created by the Western Ghats, the drought prone area of Solapur and its adjacent areas in the Deccan Plateau

receive an average rainfall of 750 mm which is distributed in 3-4 months. The rainfall is erratic and droughts are a common phenomenon.

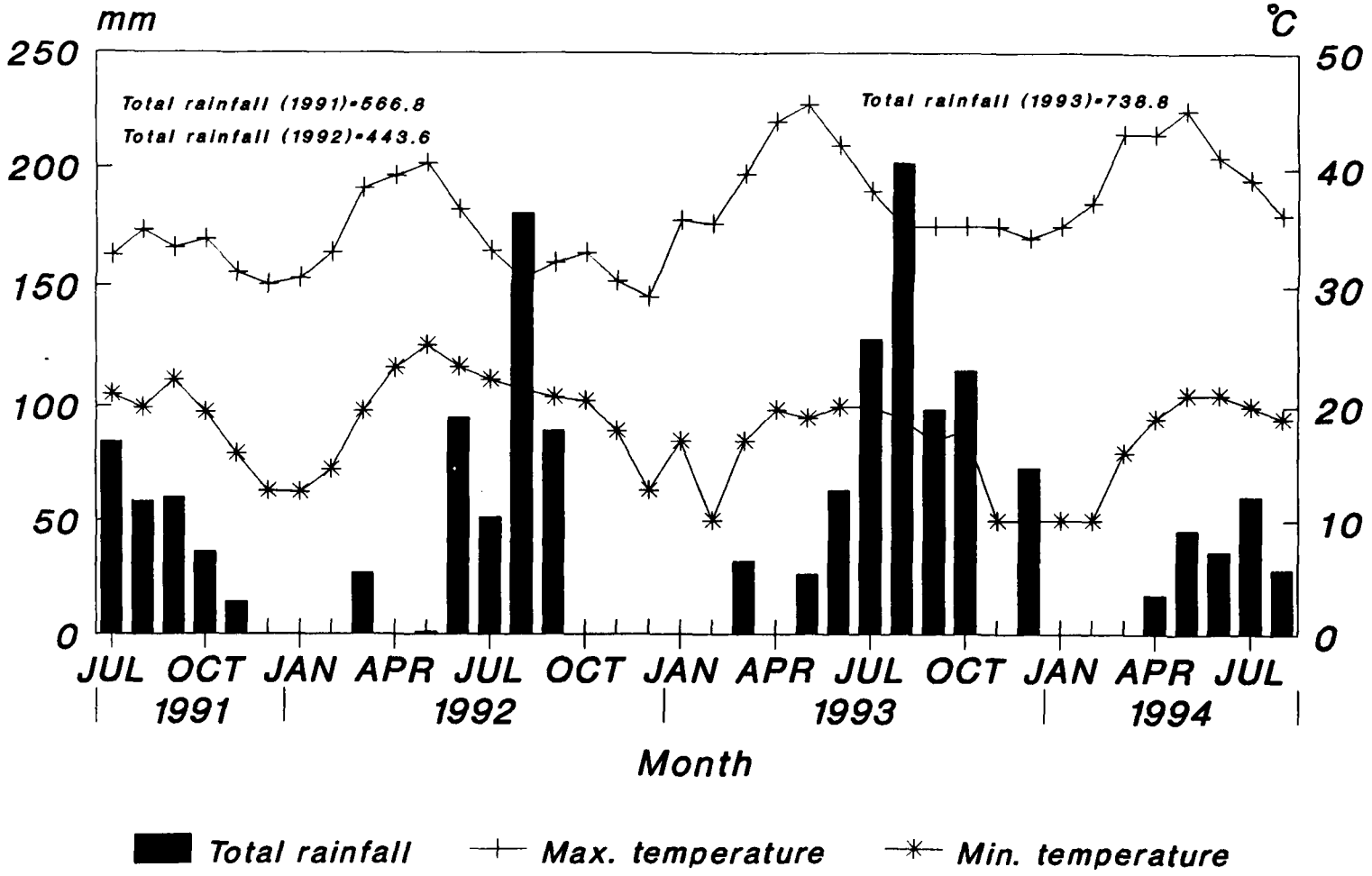
Monsoon starts in late June or early July. However, there are dry spells during late July and early August. A dry spell occurs when the rainfall in consecutive weeks is less than 15 mm. There is adequate rainfall in late August and September; more than half of the precipitation occurs in September. Rainfall ceases by mid-October. The rainfall of Solapur region varies from 500 to 720 mm and has bimodal distribution. The first peak is usually experienced during June and the second during September. The temperature between 1991 and 1994 at the Great Indian Bustard Sanctuary, Nannaj varied from 10°C (minimum) in December to 45.5°C (maximum) in May (Fig. 2.2).

2.5 Soil

The substratum comprises of half-decomposed basalt rock formations. The soil is derived from the basic igneous rock called basalt and is commonly called as black soil. The soil is low in organic carbon. The soil has high volume expansion when moist and shrink when dry producing deep cracks.

Infiltration rate is moderately slow (0.5 to 0.9 cm $hour^{-1}$). Crack development accelerates the process of soil moisture loss. Two major tributaries of River Krishna, namely Bhima and Sina flow through this area.

Fig. 2.2 Meteorological data recorded at the GIB Sanctuary, Nannaj (1991-1994)



2.6 Topography

The terrain is gently undulating with mild slopes and flat topped hillocks with intermittent shallow valleys which form the major drainage channels. These valleys have the black cotton soils which are cultivated under the rainfed regime. Grasslands are distributed in disjunct, fragmented patches forming a mosaic of grazing and agricultural lands and human settlements. Most of the grasslands are present on cultivable slopes and tops of the hillocks. These grasslands are either government owned or private and constitute the 'commons' mainly meant for grazing.

2.7 The Sanctuary

In 1975 the Drought Prone Areas Programme (DPAP) financed by the World Bank was initiated in Solapur district. The DPAP is essentially an area development programme, aimed at integrating efforts in agriculture and allied sectors to mitigate the adverse effects of drought. It seeks to develop land, water, vegetation, livestock and the restoration of ecological balance. The establishment of pastures and woodlots by the Forest Department under this scheme witnessed resurgence of wildlife, benefitted by the effective protection and improvement of the habitat. In the early 1980's, few plantation plots were established under the District Rural Development Agency (DRDA).

According to Dabadghao and Shankaranarayan (1973), the Deccan grasslands of Maharashtra are classified as *Sehima-Dichanthium* type if allowed to reach the climax stage. And where the soil is gravelly as in Nannaj area, *Sehima nervosum*

dominates. When the *Sehima-Dicanthium* cover is subjected to grazing, these communities are replaced by *Chrysopogon* (mainly *C. fulvus*) and *Bothriochloa* (mainly *B. pertusa*) species. Further grazing results in their replacement by *Heteropogon* (mainly *H. contortus*) and *Eremopogon* (mainly *E. foveolatus*) type communities. Still further grazing pressure results in a community represented mainly by *Aristida*, *Eragrostis* and *Melanocenchris* species (Fig. 2.3). The degraded sites thus have *Heteropogon-Eremopogon* and *Aristida-Eragrostis-Melanocenchris* types depending on the degree of disturbance.

The grazed lands at Nannaj exhibit the *Aristida-Eragrostis-Melanocenchris* stage. The DPAP plots are still undergoing the different stages of plant succession, with the *Aristida-Eragrostis-Melanocenchris* stage in some places, the *Heteropogon-Eremopogon* in other places and also the next stage *Chrysopogon-Bothriochloa*, and finally in some areas, it has already reached the climax stage of *Sehima nervosum*.

The area around Nannaj can be broadly divided into:

1 Protected DPAP/DRDA plots (plantation and grasslands)

2 Unprotected grazing land

3 Crop fields

The protected plots are under the control of the State Forest Department. All DPAP plots are surrounded by grazing or agricultural lands (Fig. 2.4). The DPAP plots can be sub-divided into plantation and grassland. Many new plots are coming up in the area under Social Forestry Plantation Schemes. The plantations include Subabul

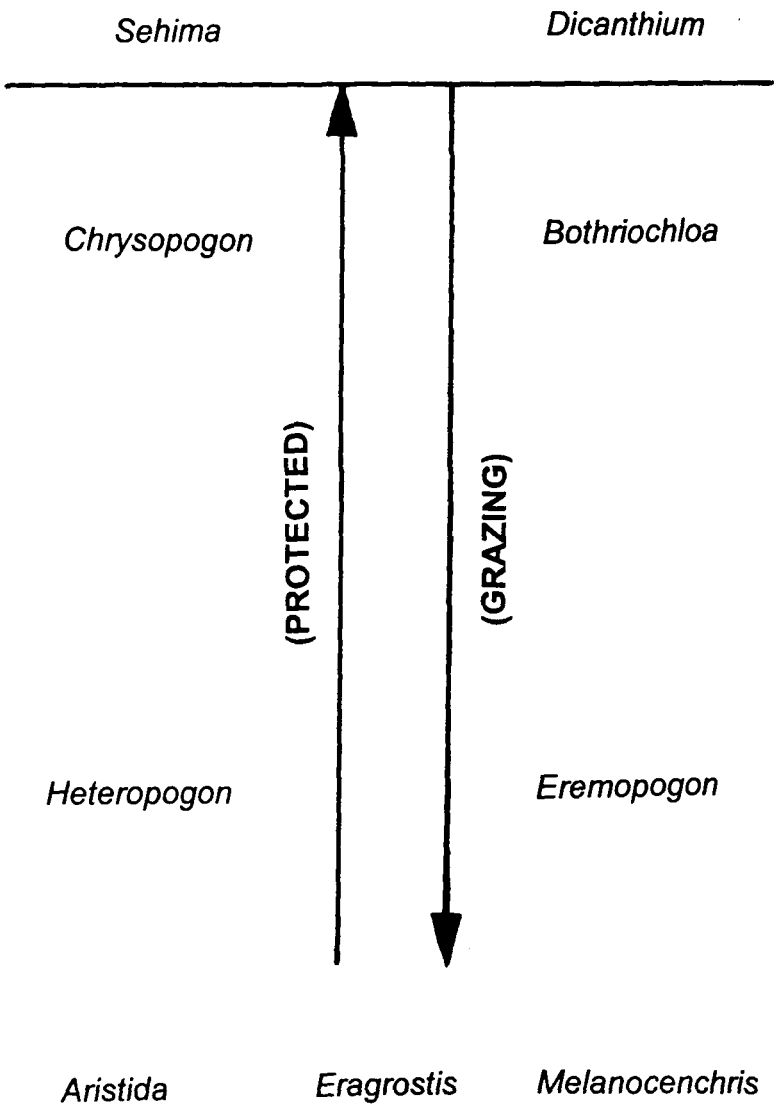


Fig. 2.3 Succession in Sehima-Dicanthium cover

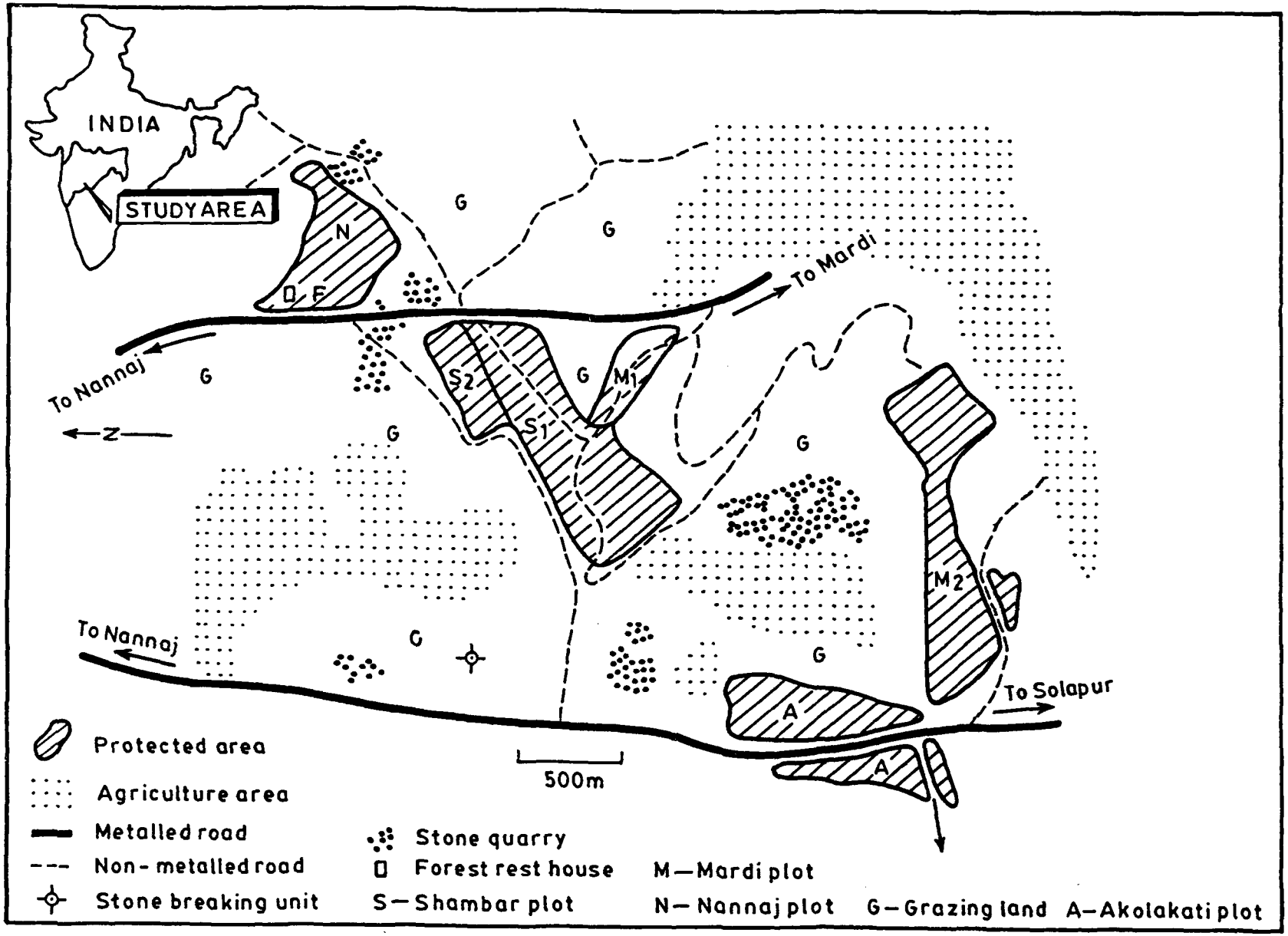


Fig. 2.4 The Great Indian Bustard Sanctuary, Nannaj (Solapur)

Leucaena latisiliqua (=L.leucocephala), Babul *Acacia nilotica*, Neem *Azadirachta indica*, Khair *Acacia catechu*, Anjan *Hardwickia binata*, White acacia *Acacia leucophloea*, Siris *Albizzia lebbeck* and Israeli babul *Acacia tortilis*.

The study at Nannaj commenced from July 1991 onwards. One of the main reasons for the selection of this site for intensive studies was long association of BNHS with the Sanctuary as well as the the presence of well protected grasslands. Nannaj provides an ideal site for studying the significance of protection on the grassland fauna from the conservation point of view with special reference to important species such as Blackbuck, Wolf and Great Indian Bustard. Moreover, protection of grasslands for bustards has created an ideal site for the prosperity of Blackbuck which resulted in very high densities of these animals. Since grasslands are not able to supply the fodder for these animals, the blackbuck resort to crop raiding in the adjoining crop fields. This is creating a conflict between the agriculturists and the Sanctuary authorities regarding the conservation issue itself.

CHAPTER THREE

GENERAL METHODOLOGY

Since the animals were not radio-collared, the individual wolves were recognized by natural marks. The Nannaj Pack was monitored on an intensive, regular basis from July 1991 to August 1994.

This wolf pack was frequently spotted at a kill between 06:00-07:00 H but rarely after 07:30 H probably because of the disturbance by the people moving in the area.

Kills of the cattle calves were not included in the analysis because of their rare occurrence. Similarly wolves' predation on the pet dogs was also excluded from data analysis because of small sample size. Therefore, livestock depredation refers to goats and sheep in the entire text. Denning period refers to the period when dens are dug and pups are born. It usually occurs in December and January.

Pups refer to the individuals less than six months of age, subadults or juveniles as 6-7 months old individuals, yearlings as 1-2 years and adults two and more than two years of age. However, it is extremely difficult to distinguish yearlings from adults in the field unless they are observed from very close quarters. The breeding period (December-August) includes denning and post-denning periods (during which the pups are reared till they start hunting on their own).

I used to be in the packs' territory by 06:00 H to look for wolf tracks and fresh droppings in the areas commonly frequented by them. In addition, I also scanned the area with binoculars in order to locate them. Sometimes crows and kites helped to locate the kill and hence the wolves. With the passage of time and experience, it was not difficult to locate the pack on kills. Once the pack was spotted at a kill, a continuous attention was paid to it until the pack members moved away from the kill. Data was collected on sex and age of the kill, biomass left unconsumed and distance of the kill from the protected area where the animal was supposedly killed. The terrain and the vegetation of the site were also recorded.

Similarly for domestic ungulates (goats and sheep), data on age, sex, location and distance of the kill from the protected area of the Sanctuary were recorded.

The weight of each kill left unconsumed and the number of wolves that were known to have fed on the kill with certainty were recorded to compute the mean consumption rate of wolves. It was not always possible to know exactly as to how many wolves were feeding on the carcass particularly at longer distances. I could overcome this problem during 1993 when four and ultimately only two wolves (Alpha pair) were left in the territory. It was possible to locate the pack of four and two wolves (Alpha pair) 11 times on the kills consecutively presuming that there was no kill besides the observed 11 kills made by wolves. Data on kills from 11 such kills was used for calculation of the average consumption by wolves and also food

consumption per day per wolf. The average weight of an adult male Blackbuck was considered to be 36 kg, of female 28 kg, subadult male 28 kg, subadult female 20 kg, yearlings 16 kg and fawn 5.5 kg (Ranjitsinh 1989, Jhala 1991).

To highlight differential predation on the wild (Blackbuck) and the domestic ungulates (goats and sheep), all the kills recorded during the study period were grouped into the following two categories:

1 Non-breeding period

2 Breeding period (denning period and pup rearing period till they learn hunting).

Non-breeding period comprised of eight months from July 1991 to November 1991 (5 months) and from September 1992 to November 1992 (3 months). The breeding period (December 1991 to August 1992) also comprised of total eight months as there was lack of data for one fortnight in February 1992 which was thus excluded from the analysis.

Chi-square, goodness-of-fit and Mann-Whitney U Statistic were used to test differential predation rates of wolves on Blackbuck and livestock and to test the predation on male and female Blackbuck, predation on goats vs. sheep. Kruskal-Wallis one-way analysis of variance was used for difference in predation (all kills) in different seasons of the wolf breeding and also the seasonality in predation patterns on livestock.

For investigating habitat use of wolf, the area was intensively searched for wolf

tracks and signs. The pack was observed directly with binoculars and spotting scope for habitat use. Whenever possible the pack was followed on foot during its movement in different areas. Usually, the pack was spotted in the morning hours around water holes or on Blackbuck kills and followed till it entered a woodlot or shaded area to rest during the day in a secluded area away from human interference. Such areas were later investigated for habitat characteristics.
Dens were located by keeping regular notice on the movement of the pack during December to January. Once a den or rendezvous site was located, care was taken not to disturb wolves by not going close to them at these sensitive sites.

During summer, Blackbuck are dispersed over a large area in low density, but congregate into large herds after it starts raining in June-July. Total count was done during this season because there is less chance of missing animals in the count. The Forest Department staff were also employed during these counts. Simultaneous counts were made for two consecutive days from 07:00 to 08:30 H on 15 July every year.

In different areas of the Sanctuary, elevated spots giving panoramic view of the area were selected for counting animals. The females were classified as adults and sub-adults.

The males were classified on the basis of the length of horns and pelage colour. Males with very short horns were called as yearling males (YM), males with short

horns and no spirals (M4), males with long horns with spirals and light golden pelage (M3), males with long horns having long spirals and rich brown pelage (M2), and black males with long horns and black pelage on the dorsal side (M1) in contrast to the white belly.

Open width transects, each one kilometre long were established in protected grassland plots, plantation and grazing land. The animals on either side of the transect line were counted and grouped into different age and sex classes. The sighting distance for each encounter was recorded. For a group of animals and large herds, distance upto the centre of the herd was measured. The animals that just ran away after starting transect count were also included in the census. On each transect census was done fortnightly.

During young stage, sex identification of juvenile females and males without spikes was difficult but after two years of age, coat colour in males turns darker from the cream colour of females, which goes on increasing in intensity and later becomes rich brown and finally dark black in adult males. In larger moving herds with individuals very close to each other, it was not possible to identify the above mentioned classes both in males and females. During such occasions, the animals were classified as adults and subadults in either of the sexes.

Density/km^2 in different habitats were computed by using the following formula:

$$D = n/2l * w$$

where l is the length of the transect trail,

n is the total number of individuals encountered during the census, and w is the sighting distance.

Every month general field notes on counts of Blackbuck with parameters such as herd-size, age and sex class in each kind of habitat in different parts of the Sanctuary were taken. The groups having individuals more than 20 were referred to as large herds and those having less than 20 animals as small herds. The data was grouped seasonally, and analysed for changes in the herd-size.

CHAPTER FOUR

BLACKBUCK POPULATION

4.1 Introduction

The most important factors which limit population of a predator are the prey base numbers and availability. It is thus imperative to gather data on the population size, age structure and sex composition of the prey species in order to understand the predation ecology of wolves.

The Blackbuck is endemic to the Indian subcontinent, being present in India, Pakistan and Nepal. The ecology and behaviour of Blackbuck has been studied by many workers (Mungall 1978a, b, 1979; Ranjitsinh 1982a, b; Prasad 1983, 1984; Prasad and Ramana Rao, 1984, 1990; Jhala 1991; and Natarajan 1994). The enactment of the Wildlife (Protection) Act 1972 has provided better protection to many wildlife species, resulting in a localized increase in the population of some animals like the Blackbuck in newly established protected areas (Rahmani 1991). The population of Blackbuck has increased in some areas after it was listed as an endangered species. The total population of Solapur district is reported to be around 3300 animals. In Maharashtra State, it is distributed in Ahmednagar, Aurangabad, Osmanabad, Bheed, Sangli, Pune, Nanded, Buldana, Akola, Amravati, Bhandara and Yeotmal districts (Rahmani 1991). Data on most of the populations are lacking.

Nannaj area in the Great Indian Bustard Sanctuary harbours a population of about 700 Blackbuck. They are seen largely in the protected grasslands of the Sanctuary as there is direct competition with the domestic ungulates outside the protected area. The population has increased after protection was given to the Great Indian Bustard. As a consequence of population increase, the animals move out to the crop-fields around the Sanctuary and cause damage. Solapur has one of the largest populations of Blackbuck within its distribution range in Maharashtra. The habitat of Blackbuck in the Sanctuary area is by and large a mosaic of marginal agricultural land and grazing land (which comprises scrubland as well as open grazed area).

The Blackbuck is repopulating many areas of Solapur after the World Bank launched its Drought Prone Areas Programme (DPAP) scheme of habitat restoration which has been successful in its aim. Besides this programme there are various afforestation schemes which are providing effective protection to the Blackbuck and other wildlife.

4.2 Methodology

4.2.1 Total counts

Solapur frequently experiences droughts. There is extreme scarcity of forage during summer. Blackbuck are thus dispersed over a large area in low density during the dry summer season, but congregate into large herds after it starts raining in June-July. Total count was done during this season because there is less chance of missing animals in the count. The Forest Department staff were also employed during these counts. Simultaneous counts were made for two consecutive days from 07:00 to 08:30 H on 15 July every year.

In different areas of the Sanctuary, elevated spots giving panoramic view of the area were selected for counting animals. The females were classified as adults and sub-adults. The males were classified on the basis of the length of their horns and pelage colour. Males with very short horns (spikes) were referred to as yearling males (YM), males with short horns (M4) without any spiral pattern and cream coloured pelage similar to a female (1-3 years old), males with long horns with spirals and light golden pelage (M3) (Fig. 4.2), face slightly darker (3-4 years old), males with long horns having long spirals and rich brown (M2) pelage (5 and >5 years old), black males with long horns and black pelage (Fig. 4.2) on the dorsal side (M1) in contrast to the white belly (10 and >10 years old). With the increase in age, the coat colour of males turn darker.

4.2.2 Line transect sampling

Five open width transects, each one kilometre long were established in protected grassland plots (2), plantation (1) and grazing land (2). The animals on either side of the transect line were counted and grouped into different age and sex classes. The sighting distance for each encounter was recorded. For a group of animals and large herds, distance upto the centre of the herd was measured. The animals that ran away immediately after starting the transect count were also included in the census. On each transect fortnightly census was done immediately after sunrise.

During young stage, sex identification of juvenile females and males without spikes was difficult but after two years of age, coat colour in males turns darker from cream

colour of females, which goes on increasing in intensity and later becomes rich brown and finally dark black in adult males. In larger moving herds with individuals very close to each other, it was not possible to identify the above mentioned classes both in males and females. During such occasions, the animals were classified as adults and subadults in either of the sexes.

Density/km^2 in different habitats were computed by using the following formula:

$$D = n/2l * w$$

where l is the length of the transect trail,

n is the total number of individuals encountered during the census, and w is the sighting distance.

The density was estimated for two sites of grasslands, two sites of grazing lands and a single site of plantation. Among the grazing land sites, one transect trail was close to the protected grassland while the second site was more than 2.5 km away from the protected grasslands of the Sanctuary. The density of Blackbuck were pooled seasonwise (summer, monsoon and winter) for all of the habitats.

Every month general field notes on Blackbuck counts with parameters such as herd-size, age and sex class in each kind of habitat in different parts of the Sanctuary were taken. The groups having more than 20 individuals were referred to as large herds and those having less than 20 animals as small herds. The data was grouped seasonally, and analyzed for changes in the herd-size.

4.3 Results

4.3.1 Population size

According to the Forest Department census records, the population of the Blackbuck at Nannaj was estimated to be around 1200 animals in 1990. My total count figure estimates the population to be about 700 which keeps fluctuating around this figure year-to-year depending on precipitation in the area and hunting pressures on the population (Table 4.1). A part of the population is also removed by wolves and stray dogs round the year.

4.3.2 Population structure

The adult males that represent the breeding units of the total population belonged only to the M1 and M2 types. The number of fawns that emerged from the total counts was an under-estimate because most of them remain hidden in the vegetation.

The distribution of the proportion of different sex and age classes is given in Table 4.2. The contribution of the adult females to the total population was highest followed by the sub-adult females (about 20%) while the adult males (M1 and M2) comprised 7.7% of the population in 1991. In 1992, again adult females constituted the highest population (68 %).

4.3.3 Sex ratio

The Blackbuck at Nannaj has two fawning peaks, one in March-April and other in August-September. Schaller (1967) in Kanha reported an all year round breeding season for Blackbuck with two peaks in March-April and August-October.

Table 4.1 Population structure of Blackbuck based on total counts in the Great Indian Bustard Sanctuary, Nannaj 1991-1994

Year	Total	Males					Total males	Females		Total females	Fawns	Sex ratio (Adults)
		M1	M2	M3	M4	YM		Adult	Sub-adult			
1991	708	30	25	18	17	30	120	431	134	565	23	1:5.9
1992	584	25	18	18	16	26	103	399	65	464	17	1:6.5
1993	577	15	21	22	18	19	95	414	43	457	25	1:7.1
1994	650*	18	25	23	21	27	114	439	65	504	32	1:6.7

* Taken from the Forest Department census records

The sex ratio of Blackbuck was found to be disproportional, i.e., 4.7 females for every male individual during 1991, 4.5 females for every male individual during 1992, 4.8 in 1993 and 4.4 females for each male individual during 1994 (Table 4.2). Different sex ratios have been reported in different isolates of Blackbuck populations by different authors. Schaller (1967) has reported sex ratio as almost 1:1 in Central India. Sex ratio reported by Ranjitsinh (1982a) for Velavadar population is 1:1.8, for Point Calimere it is 1:5.2 (Natarajan 1994). The difference in the sex ratio of the Blackbuck isolates can be due to differences in predation and selective poaching of males.

4.3.4 Mortality

The factors for mortality other than natural death are natural predators such as the Indian wolf and stray dogs. It has been found that M1 and M2 males and fawns are more prone to predation by wolves (Fig. 4.1) than any other age and sex class of the Blackbuck. Stray dogs used to hunt after rains when Blackbuck are not able to run as fast as during non-rainy days in the black-cotton soil. They also hunt fawns during summer more frequently than during the monsoon (30 out of 43 chases of fawns were seen in summer). Eighteen fawns were killed by dogs during these chases. During summer they usually move in the Sanctuary area in search of fawns. Sometimes birds of prey such as Bonelli's Eagle *Hieraaetus fasciatus* also prey on fawns of Blackbuck (Kumar 1993).

Fig. 4.2 Territorial males (M1 and M2) are usually killed by wolves than any other age class of Blackbuck.

Fig. 4.1 Fully grown Blackbuck of M3 and M1 age classes.

Table 4.2 Percentage proportion of various sex and age classes of Blackbuck

Sex and age class	1991	1992	1993	1994
M1	4.24	4.28	2.60	2.76
M2	3.54	3.08	3.64	3.84
M3	2.54	3.08	3.81	3.53
M4	2.40	2.74	3.12	3.23
YM	4.24	4.45	3.29	4.15
Adult females	60.88	68.32	71.75	67.53
Sub-adult females	18.93	11.13	7.45	10.00
Fawn	3.25	2.91	4.33	4.92
Sex ratio	1:4.7	1:4.5	1:4.8	1:4.4

4.3.5 Estimation of population density

The knowledge of the size or density of a population is often a vital prerequisite to managing it effectively (Caughley and Sinclair 1994). The maximum concentration of Blackbuck was always seen in and around the grassland Site-1 mainly because of less disturbance in this area. Thirty nine percent of the total Blackbuck kills were located at this site.

4.3.6 Seasonal variation in density

The grassland had highest Blackbuck density among all the habitats during all seasons except summer when it is less or nearly the same as in the woodlots. The variation in the density of Blackbuck between habitats and seasons is described below:

Summer 1992: The density was maximum (92/km²) in the grassland Site-1 and similar (Fig. 4.3) to the woodlot (91/km²). The density was minimum for grassland Site-2 (10 individuals per km²). The grazing land sites differed, Site-1 having higher density in comparision to the second site (Fig. 4.5).

Monsoon 1992: The grassland Site-1 had maximum number of individuals (226/km²) followed by grazing land Site-1 (Figs. 4.3 and 4.5) having density of 144/km². The density was lowest (5/km²) at grassland Site-2 (Fig. 4.3). The grazing land Site-2 and woodlot had density much lower than the other sites. This is apparently because of the availability of more forage in the grassland plots than grazing land or woodlots. A low density at grassland Site-2 was probably due to disturbance and thus less preference of this area by the Blackbuck.

Fig. 4.3 Seasonal variation in density of Blackbuck in protected plots during 1992

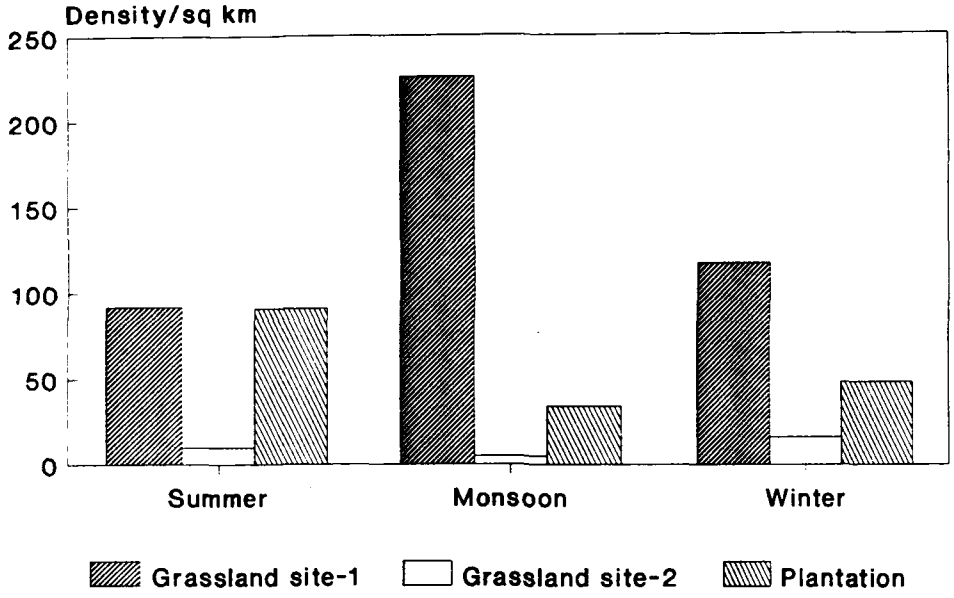
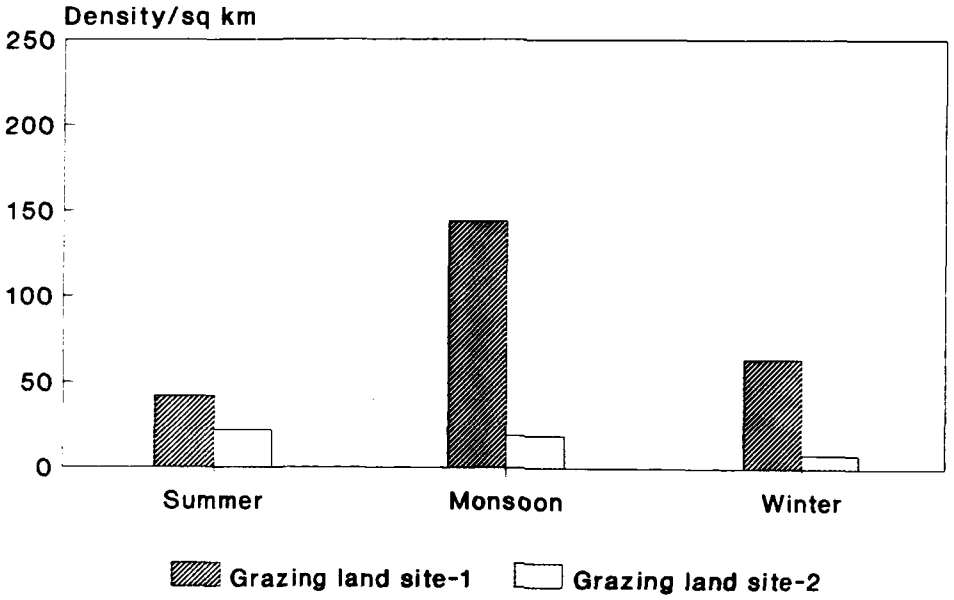


Fig. 4.5 Seasonal variation in density of Blackbuck in grazing land during 1992 during 1992



Winter 1992: The density was again high in grassland Site-1 (117/km²), while the grazing land Site-2 had lowest density i.e., 8 animals per km² (Fig. 4.3 and 4.5). Comparatively the grazing land Site-1 had higher density (64/km²). This is because of the less disturbance at grazing land Site-1 to the animals than at Site-2. The plantation had higher density during winter (48/km²) as compared to the density during monsoon (34/km²) in this habitat because of more vegetation and thus more risk of predation in the plantation during monsoon.

Summer 1993: The highest density of Blackbuck (95/km²) was found to be in the woodlot (Fig. 4.4) than the density in grassland and grazing land habitats (Fig. 4.6). The grassland Site-1 had higher number of animals (Fig. 4.4) as compared to the Site-2.

The woodlots had more number of Blackbuck during the summer because of forage scarcity in other two habitat types. During summer, sometimes the animals move into the woodlots for resting in the shade.

Monsoon 1993: The density was highest in Site-1 of the grassland as well as the grazing land (Fig. 4.4 and 4.6). The density was found to be the same at Site-2 of the grassland and grazing land (6 individuals/km²).

Winter 1993: The density was more for both of the grassland sites in comparision to the density during the monsoon (Figs. 4.4 and 4.6). And the plantation had quite low density as compared to the monsoon (11/km²).

4.3.7 Seasonal variation In herd size

The herd-size varied between the habitats and between the seasons. We found that the Blackbuck congregate in large herds during the monsoon because of the forage

Fig. 4.4 Seasonal variation in density of Blackbuck in protected plots during 1993

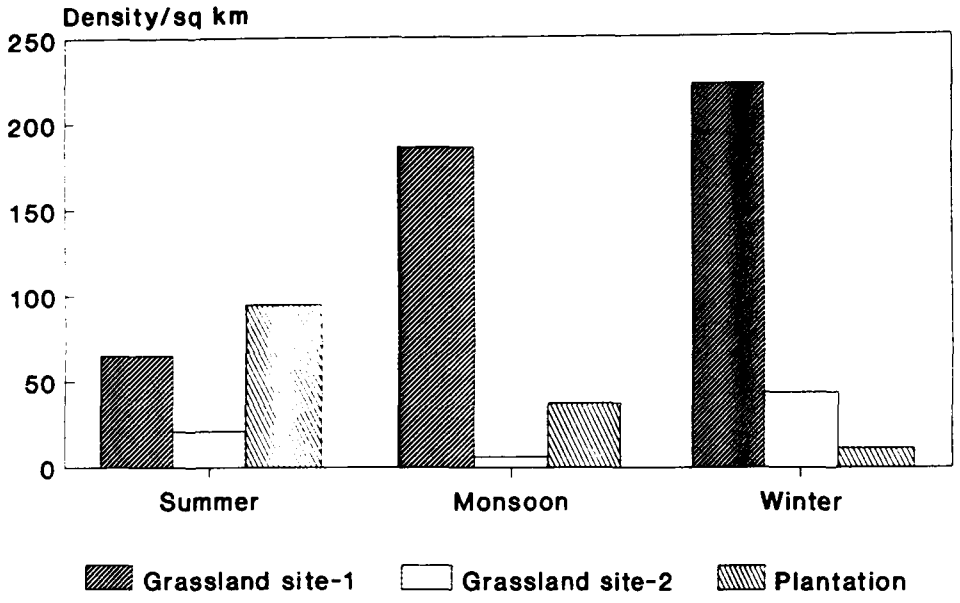
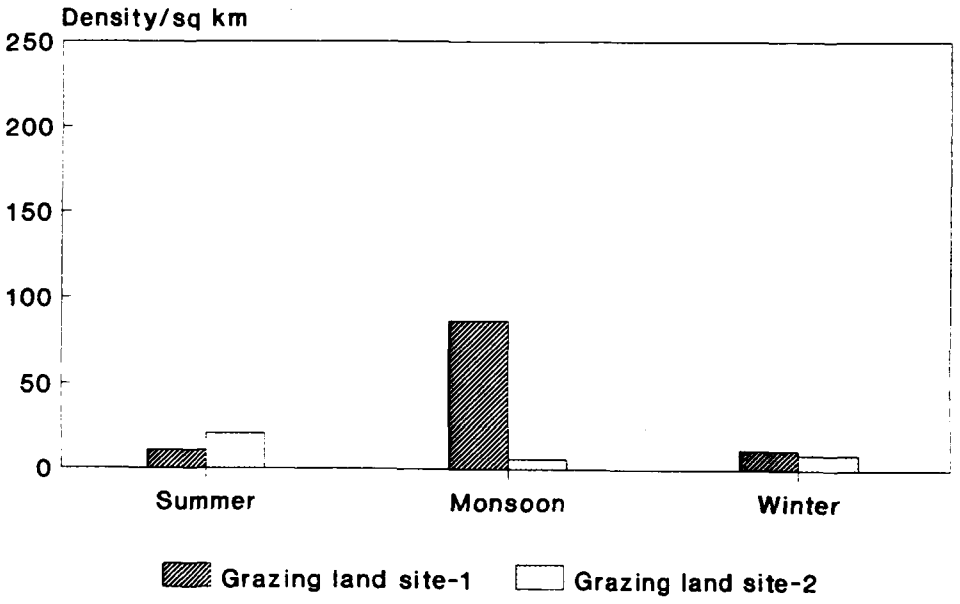


Fig. 4.6 Seasonal variation in density of Blackbuck in grazing land during 1993



availability in the form of fresh grass growth. On the other hand, they break into smaller units during the dry summer season and spread over a vast area. The herd-size classes of 9-16 and 17-32 individuals were seen more frequently than any other class in all the seasons whereas sightings of herds comprising more than 200 individuals were low. The higher frequency of occurrence of the smaller herd-size classes in all the seasons is perhaps to prevent overgrazing which results because of immense competition for food amongst large number of individuals. The different herd-size classes seen over three years is given in Table 4.3.

In 1992, there had been drought and the frequency of sighting of large as well as small herds was low in comparison to the year 1991. The maximum number of solitary males were seen during July-August and February-March which is the rutting season of Blackbuck.

4.3.7.1 Social units or groupings

The mixed herds were most common among all the social groupings in the Blackbuck. The pseudo-harems were common during monsoon when the female dominated herds (with small yearling and subadult males) or female herds used to pass through the solitary males (sometimes bi and/or trio groups) dispersed over an area. Structurally, the following types of herds were observed during the entire study period: herds with one male and several females, herds with several males and several females, and bachelor groups. All such herds were seen with small ($\bar{X}$=12.6, s.d.=4.3) as well as large (x=96, s.d.=59.9) number of individuals.

Table 4.3 Distribution of herd-size classes of Blackbuck in different habitat types (1991-1994)

Season and habitat type	Herd-size classes									
	1	2	3-4	5-8	9-16	17-32	33-64	65-128	129-256	>256
Monsoon 1991										
Grassland	324	7	8	15	24	39	32	22	15	3
Grazing land	42	26	24	23	32	19	23	13	13	1
Plantation	1	1	2	4	7	4	2	2	0	0
Total	367	34	34	42	63	62	57	37	28	4
Winter 1991										
Grasslansd	240	3	7	6	15	25	15	20	4	0
Grazing land	50	4	7	13	14	10	6	6	1	0
Plantation	16	1	1	1	6	0	0	0	0	0
Total	306	8	15	20	35	35	21	26	5	0
Summer 1992										
Grassland	54	2	2	4	5	4	2	0	0	0
Grazing land	17	6	4	1	9	4	2	2	0	0
Plantation	1	1	3	1	2	2	0	0	0	0
Total	72	9	9	9	16	10	4	2	0	0
Monsoon 1992										
Grassland	306	4	15	12	10	21	22	14	7	5
Grazing land	38	8	8	19	25	28	18	15	11	0
Plantation	22	1	3	4	4	1	4	1	2	0
Total	366	13	26	35	39	50	44	30	20	5
Winter 1992										
Grassland	102	5	2	5	14	10	15	2	1	0
Grazing land	19	4	7	13	10	10	4	7	0	0
Plantation	4	0	1	0	0	2	1	1	0	0
Total	125	9	10	18	24	22	20	10	1	0
Summer 1993										
Grassland	155	11	15	14	15	17	5	1	0	0
Grazing land	57	15	19	19	31	19	8	1	0	0
Plantation	6	1	1	1	1	2	0	2	0	0
Total	218	27	35	34	47	38	13	4	0	0
Monsoon 1993										
Grassland	110	10	5	10	18	15	5	6	2	0
Grazing land	34	13	16	17	23	11	4	4	2	0
Plantation	2	3	3	0	1	0	1	0	0	0
Total	146	26	24	27	42	26	10	10	4	0

Sometimes very large herds ranging up to 300 individuals were sighted in the evening hours (1800 H) while they were on the move after grazing or in the morning around 09:00 H when they had settled for rest in the open area. These were the mixed herds formed as a result of grouping together of many smaller groups representing all age-classes.

4.4 Discussion

Population size plays a central role in wildlife management. Effective management plans of wildlife populations are often based on population size of the species, conversely, population size is thus the tool by which the success of a management program is ultimately judged. Among all of the habitat types during both the years, density was highest in the grassland Site-1 during the monsoon and the winter. The density were always low for Site-2 (grassland as well as grazing land) because of minimal usage as disturbance to animals was more prevalent in these areas. This was mainly because of the disturbance by the cattle graziers and the labourers working at the stone quarries. When the density of Blackbuck was compared across three seasons, monsoon had higher density in the grasslands. This could be due to fresh growth of grass in the protected grassland plots in Nannaj. In the grazing land, on the other hand, as soon as fresh grass comes up, it is grazed by livestock, so not much is left for Blackbuck. In 1993, the grassland had low density during monsoon as compared to the density during winter probably because of the late arrival of the monsoon and prolonged rains which continued till December.

In the plantation plot, Blackbuck density was highest during summer and lowest during monsoon. During summer, when very little food is left in the grazing land and grassland, the Blackbuck move inside plantation plot for forage and shade. Moreover, during summer most of the tall, coarse grasses start dying and the plantation plot becomes open, while during the monsoon, just the opposite occurs. Food is plentiful everywhere, so the Blackbuck move in a wider area. Secondly, vegetation in the plantation becomes dense and tall, which the Blackbuck avoid.

As the monsoon was again delayed in 1993, there was inadequate fresh vegetation in the plantation plot, so less number of Blackbuck were found there. In all the years during our study period, the density in grassland was found to be low in summer. This is because the grasses during this season are dry as a result of which the Blackbuck are dispersed over a large area in search of forage. From summer to monsoon there is a marked increase in their density both in the grassland and the grazing land (decline in the plantation) whereas fall from monsoon to winter when the larger herds start breaking into smaller groups.

The herd-size of Blackbuck varies between the seasons, perhaps due to changes in forage availability. The pre-monsoon showers with the fresh grass growth in the pastures make Blackbuck congregate into large herds even prior to the onset of monsoon. The grazing land also has large congregations which depends on the cyclic grazing activity of livestock during daylight hours. They are frequently seen grazing in the grazing land during early and late hours of the day when livestock is absent. During drought years, when the grass is scarce, they chew blades of *Agave*

americana (which has been used as a fence to prevent the entry of livestock into the protected grassland and woodlot plots of the Sanctuary) and the *Tridax procumbens* which is the only green herb other than the sparsely distributed grass species *Chrysopogon fulvus* available during this season. During such unfavourable periods they also consume leaves of *Acacia leucocephala* and *A. nilotica* more frequently than at other times. During summer, due to intense competition, the group size was low and herds consisting of 2 to 16 individuals were often seen, and sighting of even moderate-size herd (about 30 individuals) was uncommon (Table 4.3). This splitting up of groups into smaller units when food resources are depleted is to avoid competition for forage. On the other hand, during monsoon as well as winter, the frequency of sighting of groups having more than 30 individuals was also higher during these seasons.

Large herds were sighted in open areas whereas smaller groups in the plantation which may have been evolved as an anti-predator strategy. Smaller groups may be able to remain undetected in the plantation cover. On the other hand, in an open grassland, the probability of spotting a predator by a large herd and thus becoming alert for self-defence is more than in the area with more vegetative cover. Nevertheless, wolves manage to locate sick individuals from large herds too and chase them off from the herds.

CHAPTER FIVE

POPULATION: STATUS AND DISTRIBUTION

5.1 Introduction

In order to manage populations effectively, it is essential to know their general characteristics. Therefore, knowledge of the population size is vital prerequisite to managing it.

Wolves are considered dangerous to man directly as well as indirectly and hence persecuted all over their range in India. Despite all these factors, a viable population of the Indian wolf exists in the country. In Maharashtra, the wolf is distributed in small pockets of semi-arid areas comprising Nasik, Aurangabad, Jalna, Buldana, Akola, Yavatmal, Ahmednagar, Beed, Pune, Satara, Solapur, Osmanabad and Sangli (Fig.1.1) (Kumar and Rahmani 1997).

It is difficult to make accurate estimates of wolf populations because the animals are elusive, occurring in relatively low densities, and they travel over a large area (Mech 1973). Owing to this, the few estimates of wolf numbers which have been made anywhere have varied greatly in precision and area covered. Many areas of the Great Indian Bustard Sanctuary were surveyed during this study to estimate wolf numbers and wolf density. The wolf density varies in relation to the density of prey base. Nevertheless, the various methods of estimating wolf density and abundance available in literature are non-statistical because no sampling was done.

The wolf exists in marginal areas of the Great Indian Bustard Sanctuary and there is a tremendous livestock pressure on these areas because of continuous increase in livestock. Except for the preliminary surveys by Shahi (1982) and studies on wolf in Velavadar National Park in Gujarat (Jhala 1991, Jhala and Giles 1991), there is lack of ecological information on this subspecies in other areas of its distribution. While on the Tibetan wolf, nothing exists on its ecology and population estimates in India and other areas of its distribution (Mech 1982). The longest study on wolf numbers and its prey has been conducted in Isle Royale National Park, Lake Superior where wolves have been censused annually since 1959 (Jordan *et al.* 1967, Mech 1970, Wolfe and Allen 1973, Peterson 1977, Peterson *et al.* 1984).

This chapter provides basic information on the status of the wolf population. A brief account of the study area is given here again about the survey sites.

5.2 Study Area

Solapur having an area of 15,017 km^2 is one of the largest districts of Maharashtra both in terms of area and human population. It lies in the interior Deccan and represents typical of the plateau. The climate is dry and resembles that of the intensive study site- the Great Indian Bustard Sanctuary, Nannaj (see Study area). The year to year fluctuation in rainfall distribution makes the area drought prone.

Large-scale plantations are being raised by the State Forest Department in all the sub-divisions. The main purpose is to check soil erosion, provide firewood for local people, fodder for cattle and to provide vegetative cover to soil. These plantations are being established under different agencies such as Drought Prone Areas

Programme (DPAP), District Rural Development Agency (DRDA), Employment Guarantee Scheme (EGS) and Tree Planting Scheme (TPS). The State Forest Department under its conservation and soil protection schemes, with the above agencies has raised more than 500 plantation plots in Solapur district alone. These plantation plots range from 15 to 500 hectares, and provide excellent cover during summer to the wolf and its prey. These forest plots also serve as undisturbed denning sites.

The chief mountain-passes ("ghats") in the district are: Yedshi ghat in Barshi, Waghola and Bodki in Karmala, Chinchgaon in Madha, Gurvad and Phalten range in Malshiras and the Khanapur-Jat hills in Sangola.

The main crops are Sorghum *Sorghum bicolor*, Sunflower *Helianthus annus*, Wheat *Triticum aestivum*, Sugarcane *Saccharum officinalis*, Groundnut *Arachis hypogea* and various pulses. There are orchards of Grapes *Vitis vinifera* and Indian plum *Zizyphus mauritiana* in the areas which are under well-irrigation. Sorghum and Sugarcane are the main crops in irrigated areas. The dominant grasses include *Aristida* spp., *Sehima nervosum*, *Heteropogon contortus*, *Dichanthium annulatum* and *Chrysopogon fulvus* interspersed with scattered scrubland.

5.3 Methodology

A survey of the wolf and its prey was conducted in Solapur and its adjoining districts during November-December 1993. Information on the presence of wolf, breeding, number, natural prey, livestock density and public attitude were taken on a set proforma through inquiring and/or by ground surveys. Forest Department

personnel, villagers, particularly shepherds were interviewed. Information collected from people was cross-checked by ground surveys by looking for scats and tracks and sightings or howling. Those areas, where wolf presence was not expected such as intensive agriculture areas, were not surveyed intensively. In such areas the crop is harvested twice a year and the area is always occupied and frequented by humans. To avoid over estimation, the queries with one source about wolf numbers were tallied with information gathered from other sources in a particular area.

Maximum information was sought from the shepherds about the frequency of wolf sighting in a particular area, constancy of the pack-size and wolf breeding in the area. If I found evidence of denning in a particular area, then the informer was accompanied upto den sites and the necessary information was collected.

All the eleven sub-divisions (Tehsils) of Solapur district were surveyed thoroughly and the areas wherein wolf presence was known were checked with intensive search operations by looking for tracks and scats (as sighting is rare). The sub-divisions are: Akkalkot, Barshi, Karmala, Madha, Malshiras, Mohol, Mangalvedha, North Solapur, Pandharpur, Sangola and South Solapur. Malshiras, Sangola and Barshi tahsils have steep hills and the rocks are in the form of medium to large-sized boulders. Akkalkot, Pandharpur, Mangalvedha and Madha have the largest agriculture belts, thanks to the development of irrigation facilities. The crops are also irrigated from the river Bhima in these sub-divisions. These areas have incurred heavy increase in agricultural area and the grasslands are continuously being converted into crop fields because of improved irrigation facilities.

In addition to the revenue land and grazing land, plantations, totaling 5,125 ha were surveyed. A distance of 2,776 Km was covered by vehicle during the survey and indirect evidences of wolf were collected. The plantations were dispersed over a large area of grassland and crop fields.

The wolves found within 20 km radius around villages were considered as one pack moving over these areas. This was tallied/confirmed with the number of wolves seen in these villages also (i.e., if the same number of wolves were sighted around 4-5 villages, it was considered as one pack). In total 398 people were interviewed about wolf and its whereabouts.

5.4 Results

Prior to my study, in 1990-91, the Nannaj Pack bred but the pups were killed by villagers by blocking and fumigating the den. The pack had used the Reinforced Concrete Cement (R.C.C.) pipe as a den. The den was very close to crop-fields. Therefore, the pack comprised only yearlings and adults in 1991 when this study started.

5.4.1 Population

At the outset of this study in July 1991, there was a pack of seven wolves which increased to 12 during 1992 by successful breeding and rearing of five pups. The composition of the pack during 1991 was four males and three females. All the seven wolves had attained adult size and were indistinguishable from each other with respect to size. Once the pups had attained an age of about nine months, it

was difficult to differentiate them from the adult wolves. The subadults started dispersing when they were 9-10 months of age during September-October. During this time, the pack members disassociate and reassociate several times before a single pack stays back in the territory. From September 1992 to February 1993, the pack of 12 wolves was observed to get divided into smaller units and then reuniting till a pack of only two individuals was often sighted in the territory. By March 1993, the pack had dispersed and only two wolves were left in the territory. The sex composition of the Nannaj Pack (1991-1994) is given in Table 5.1.

There were two more packs adjacent to the Nannaj Pack. **Gangewadi Pack** was present 20 km (linearly) northeast from the centre of the territory of **Nannaj Pack**. This pack comprised of five wolves. In 1993, only three wolves were seen twice in Gangewadi Pack. Another pack named **Mohol Pack** was present in Mohol area, 25 km (linear distance) west of the territory of Nannaj pack. This pack also comprised of seven wolves that increased to 14 in 1992 but dropped to four wolves in 1993. The Nannaj Pack did not breed during 1992-93 which was a drought year. A pack of five and four wolves was sighted in the territory of Nannaj Pack that was apparently another pack (probably Gangewadi Pack) making forays into the territory of Nannaj Pack. The Nannaj Pack was seen twice chasing another pack members along the periphery of their territory on the east. During 1993-94, the Nannaj Pack again bred successfully and reared five pups.

The sex ratio of the wolf population was biased towards males in 1991 while equal in 1992 and 1993. The sex ratio of the 1994 population was not known (Table 5.1).

Table 5.1 Numbers and sex composition of the Nannaj wolf pack

Year	Adult		Subadult		Unsexed	Total
	Male	Female	Male	Female		
1991	4	3	_	_	_	7
1992	4	3	2	3	_	12
1993	1	1	_	_	_	2
1994	1	1	_	_	6	8
1995	1	1	_	_	4	6

The wolf is present in all sub-divisions of Solapur (Fig. 5.1). The results of the survey for population estimates and density per 100 sq km in different areas are given in Table 5.2. Solapur district supports a minimum population of 53 and maximum of 85 wolves. Out of these figures, the packs that are present along the district boundaries (e.g., with Ahmednagar, Satara, Sangali and Osmanabad) and the state border (Karnataka) contribute to populations of either side. Much of the range is inhabited by low pack-sizes. The largest pack-size comprised of 12 wolves and smallest of two individuals. This is because of the high human populations in such areas and disturbance. Moreover, the natural prey base and livestock (goats and sheep) are also low in these areas. There was no constancy in the pack-size in any area of the wolf range as reported by different people. For example, the Nannaj Pack that was followed for behavioural studies, did not remain constant over the year. Most of the sightings during winter were of only two animals. I presume that this might be a result of more activity of the alpha pair of a pack or the only pair (lone pair) of an area searching denning sites.

The Blackbuck (primary prey of the wolf) is in low numbers in most of the wolf range areas of Solapur except Mohol and North Solapur sub-divisions which harbour large populations of Blackbuck (Table 5.2). Indian gazelle or Chinkara (*Gazella bennetii*) was seen only in three sub-divisions of Solapur (Table 5.2) in extremely low numbers.

About 12-15 years ago, the wolf disappeared from Achegaon and surrounding villages in South Solapur and Narliwadi and surrounding areas of Sangola tahsil apparently because of agricultural expansion and change in cropping pattern. For

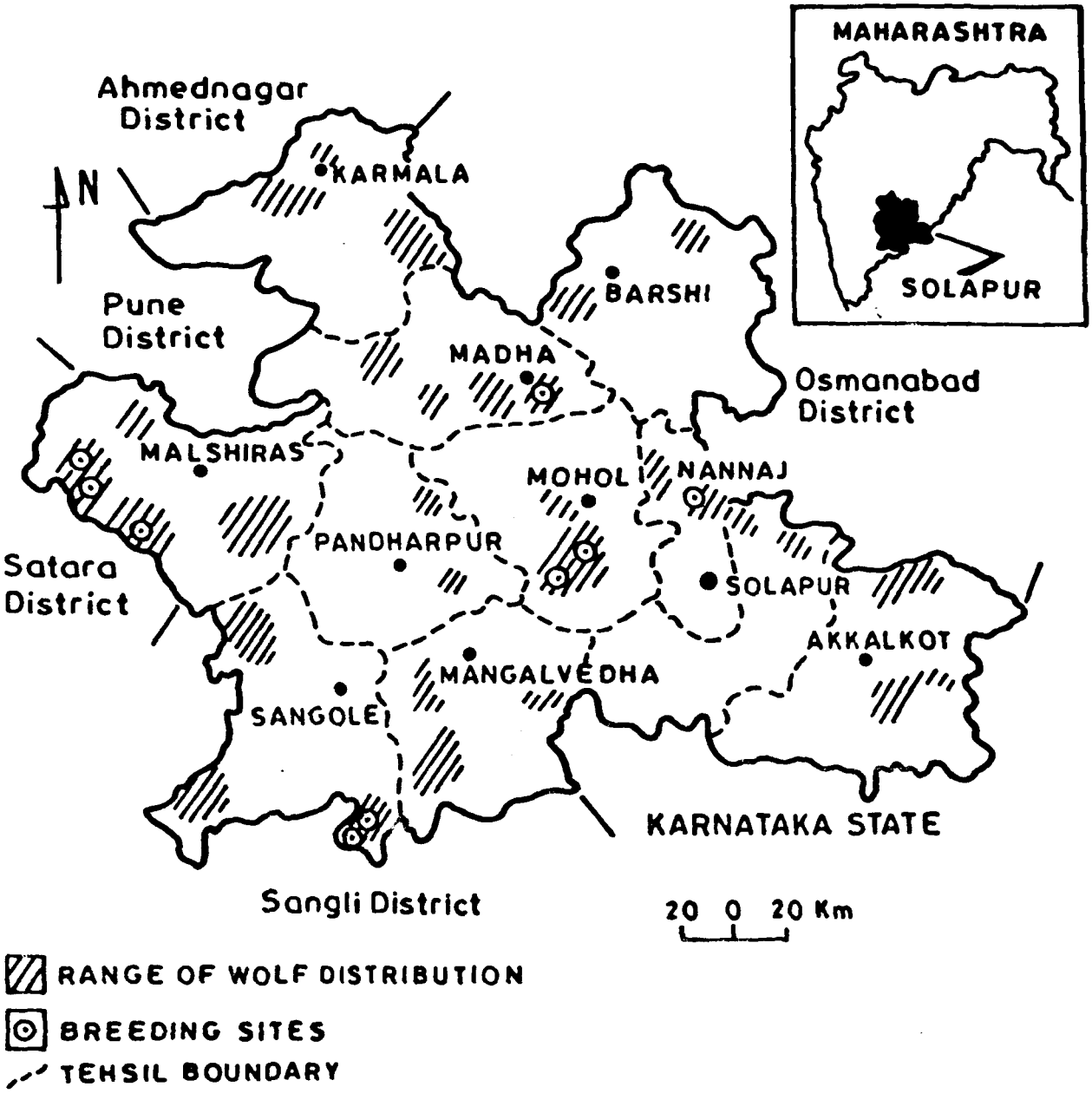


Fig. 5.1 Distribution of Indian grey wolf in the subdivisions of Solapur, Maharashtra

Table 5.2 Approximate density of wolves and their natural prey populations in Solapur subdivisions

Sub-division	Area** (km^2)	Wolf density (per 100 km^2)	Natural prey	
			Blackbuck	Chinkara
Akkalkot	199.26	4	30-50*	_
Barshi	246.09	3	100-120*	(2)
Karmala	278.09	3	400-500*	(11)
Madha	287.77	1	200-250*	_
Malshiras	362.05	3	Not known	(2)
Mangalvedha	169.26	2	Not known	_
Mohol	229.38	3	2000* (500-550)	_
Pandharpur	219.21	1	About 500* (76)	_
Sangola	164.98	5	Not known	_
Solapur North	242.03	4	1000-1200* (700±)	_
Solapur South	151.86	4	150-200* (182)	_

* represents the numbers supplied by the local people and the Forest Department
** wolf habitat or area available to wolves
numbers in parentheses represent my observations

the same reasons, the range of wolf has shrunk in Mangalvedha and Madha tahsils. Breeding was noticed only in Akkalkot, Madha, Malshiras, Sangola and North Solapur tahsils, which still have extensive areas under marginal cultivation.

After being bitten by a wolf in 1991, a young shepherd of Jalbhavi village died in September 1993 due to rabies. There was a pack of 14 wolves in 1991 in this village area and one was infected with rabies. In recent years, this is the first and only case of human casualty by wolf in Solapur district.

5.4.2 Fluctuation in pack size

The complete pack was sighted rarely but few individuals of the pack were seen frequently throughout the year. In 1993, usually two wolves were seen in the Nannaj Pack but sometimes all the 12 individuals of Nannaj Pack joined together in loose association. Usually the larger pack starts breaking into smaller units prior to mating season because of which there was wide fluctuation in the pack size.

There was a fluctuation in average pack size during non-breeding and breeding periods but it was statistically non-significant (Mann-Whitney U Test, U=10, P=0.16). The average pack size during breeding and non-breeding seasons varied from 1.5 to 4.7 individuals.

Of 497 observations on wolves in the Great Indian Bustard Sanctuary, Nannaj, maximum (47%) were of more than two wolves, 33% were of two wolves, 19% of a solitary wolf and minimum (1%) of 12 wolves.

Jordan *et al.* (1967) have recorded a maximum pack of twenty-two wolves from Isle Royale. The pack size varies markedly throughout the year. According to Raush (1967), a large pack would mean either a high production of pups or chance meetings of individuals. Probably due to chance meeting (if sometimes the individuals are able to recognize their earlier pack-mates/lineage) on 13 July 1993, a large pack of 13 wolves was seen in the territory of Nannaj Pack although earlier only two wolves were left in this territory.

5.4.3 Mortality

Wolves die from a variety of causes: malnutrition (Van Ballenberghe and Mech 1975), disease (Chapman 1978, Carbyn 1982), debilitating injuries (Mech 1970), interpack strife (Van Ballenberghe and Erickson 1973, Mech 1977, Peterson 1977), and human exploitation and/or control. At Nannaj, during the breeding period in winter, there are many threats to wolves by humans. They are highly prone to mortality during this period because once an active den is located by shepherds (by chance or by search efforts), the pups in all probability are killed. The shepherds fumigate the dens and sometimes block the den entrance(s). The wolves are prone to high mortality by humans during the entire summer period because livestock depredation in this period is more. The disgruntled shepherds use poison to kill wolves. Wolf hunting and trapping activities were not recorded at the study site. The fall in pack-size after September-October can either be attributed to dispersal or mortality (?).

Two dead wolves were recovered in 1992: one in September which probably died because of rabies and another in October that was killed by shepherds. No

mortality in pups was recorded after they left the dens and were six to seven months old.

5.5 Discussion

Pulliainen (1980) and Mech (1982) have mentioned that viable populations of the wolf are found only in Alaska, Canada and parts of north-central U. S. A. (Minnesota) in the Nearctic region, and in Finland, the Soviet Union, Iran and Yugoslavia in the Palearctic region. Originally, the wolf was distributed in suitable habitats throughout the northern hemisphere, but during the last century its range has decreased considerably, mainly due to persecution by man and various factors of habitat destruction and prey decline. In this respect, the history of the wolf in India has been no exception. Similarly the wolf has been declining throughout Europe during this century.

The wolf population has witnessed some resurgence in Nannaj area after establishment of the Great Indian Bustard Sanctuary in 1980. Sighting wolf in this area was rare during the bustard study conducted under the Endangered Species Project from 1981-1984 (see Table 2.1 Study area).

During my study period from 1991 to 1994, the pack-size at Nannaj was found to fluctuate every year which could be a numerical response of wolves to change in prey density or rather availability of vulnerable prey. In 1992 the population increased from seven to 12 wolves which again dropped to two animals in 1993. This drastic decline in pack-size could have been in response to drought in 1992 the impact of which remained till June 1993. Every year from September onwards

the pack starts breaking into smaller units probably either due to the suppression by the alpha members to breed or increase in competition for food because by this time the pups (subadults) are also fully grown. After the population starts dispersing, whether loners establish elsewhere by finding mates and mark their territories or not is not known. Wolves have been known sometimes to shift their focus of activity to other less used parts of the territory (Mech 1970).

CHAPTER SIX

HABITAT USE AND PREFERENCE

6.1 Introduction

The abundance of animals and distribution of their populations vary in space and time, often with the availability of the environmental components necessary for life (Litvaitis *et al.* 1994). Each species exploits a set of resources, so an understanding of the habitat and food use by a species is necessary before any management efforts are initated. Habitat selection is a complex multidimensional, multiscaled process (Morrison *et al.* 1992; White and Garrot 1990).

Animals use certain environmental cues such as vegetative cover, landform, slope aspect etc. while settling in a habitat. These cues are called as proximate factors. After a site is evaluated by an animal, certain factors such as food availability, and ability to reproduce influence its habitat selection. Such factors which rule or govern how successful an animal is within a particular habitat are referred to as ultimate factors.

The Great Indian Bustard Sanctuary at Nannaj falls in the semi-arid region which comprises of predominantly grazing land. The habitat composition may vary temporally, seasonally and the animals may accordingly change their pattern of use of different habitat types. The choice of a particular habitat has the effect of placing

the animal in a particular environment and habitat selection thus has profound consequences (Partridge 1978). The distribution and movement of Blackbuck may function in a way that could influence habitat use by wolves.

Other than habitat use and preference, this chapter also describes selection of rendezvous sites (RS) by wolves. Data have been collected to determine what parameters are important in selecting a particular rendezvous site, e.g., cover at the site, distance from water source and prey density.

The major aim of this section of the study is to examine habitat use by wolves and to gain insight into the criteria used in habitat choice. The key factors which govern habitat selection of wolves are cover, water availability, potential denning and resting sites. All these environmental variables interact with each other resulting in animal distributions.

Water availability is a limiting factor for the distribution of wolf. It plays a critical role in the life of wolves particularly in summer when water dries up from all the ephemeral sources of water.

6.2 Methods of Data Collection

Some elevated spots were selected in the study area in order to locate wolves. It was difficult to locate them inside plantations because of dense foliage, but since they used to regularly come to the waterholes during different hours of the day, so

the possibility of locating them around plantations was as much as for the remaining habitat types. The wolves were sighted in plantations during hot hours of the day particularly after they visited waterholes and returned to the plantation. The wolf observations otherwise for this habitat would have been underestimated.

The Nannaj Pack ranged over an area of about 20 Km^2. Each observation on wolves in grassland, grazing land, scrubland and plantation was plotted on a 1:25000-scale map of the study area. A group of wolves sighted in these habitat types was considered as one observation.

All these observations of wolves relative to use and occurrence of habitat could be used as long as the following two assumptions described by Neu *et al.* (1974) are met:

- the animals have an opportunity to select any of the habitat which is available and
- the observations are collected in a random, unbiased manner.

Cover was estimated by Point-centred quarter (PCQ) (Muller-Dombois and Ellenberg 1974) method by establishing one kilometre transects (or less than one km if the patch was smaller) in the scrubland and plantation habitats of the area. The shrubland type of the vegetation is patchily distributed in the area so a minimum of two transects were established in each patch of the scrubland 20-25m apart. Twenty eight transects selected randomly in scrubland and plantation

patches were sampled for computing vegetative cover to later assign its value or importance to the wolves.

Sampling points were taken at a distance of 15-20m depending on homogeneity or heterogeneity of the habitat. The vertical and the horizontal diameters of the crown of the plant were recorded. Density, cover, frequency, relative frequency, dominance, relative dominance, for each species were computed with the help of a package **SBPOINT** (Rao and Javed unpublished BASIC programme).

The variables such as human disturbance, Blackbuck density, livestock density, distance from water source, distance from stone quarries were measured in each patch. Also the wolf sightings at each patch were recorded to relate the influence of these variables on wolf use of that area.

Percent wolf use for each rendezvous site was calculated from the total number of wolf observations and/or sightings and related with percent cover available at the site.

The number of wolves visiting a waterhole were recorded at all three water sources in the study area. A hide was constructed at a distance of 200m at one of the water holes located at grassland plot (M2). Two field assistants also assisted in monitoring wolves around water holes holes which otherwise would not have been possible. Observations on wolves at waterholes located in S1 and M1 were taken from the

hut present in S1 plot (Fig. 6.0) The number of wolves coming to the waterholes and time of visit were recorded. Waterhole usage by the pack was continued for two years 1992 and 1993.

6.3 Analyses

To find out seasonal habitat use by wolves, observations for different habitat types were pooled seasonally for statistical analysis. Since the habitat use by wolves did not vary year-to-year so the entire data were put together.

To find out habitat use of wolves during different hours of the day, all observations were categorized into three classes: 06:00-10:20 H, 10:20-14:40 H and 14:40-19:00 H. The sample size was large enough to analyse and find out if they used specific habitat types during specific time period of the day.

Principal Component Analysis (PCA), a multivariate statistical technique was performed on the habitat variables to find out selection of the rendezvous sites by the wolves. Arcsine transformation of data was done for the variables measured in percentages and log normal transformation for the remaining variables to bring their values on zero to one scale (Zar 1984).

The purpose of performing PCA was to find out what are the important variables in selecting a particular site as a rendezvous site. Statistical packages SYSTAT 4.0 (1988) and STATA 5.0 (1997) were used for analysis of the data. For some analysis

Fig 6.0 Observation hut from where wolves were observed at water in Shambar (S1) and Mardi (M1) plots, arrow pointing out the hut

SPSS Advanced Statistics 6.1 (1994) was also used. Another purpose of PCA was to reduce the dispersion of the data and present the large proportion of information contained in the original, unvisualizable data into two-dimensional or three-dimensional plane. The latter reveals the real pattern of the data most clearly.

There was no difference in habitat use in a particular season for a particular year. Therefore, the data for a particular season for the study duration was grouped (pooled across years for the season).

6.3.1 Hypothesis: The wolves utilize each habitat category in exact proportion to its availability within the study area.

The statistical validity of the hypothesis that wolves use different habitat types in proportion to their occurrence was tested with the chi-square Goodness-of-fit analysis. After establishing the relationship of habitat use in different seasons as well as different hours of the day, the preference or avoidance of a particular habitat type was determined by calculating simultaneous Bonferroni confidence intervals (Neu *et al.* 1974; Byers *et al.* 1984; Griffith and Peek 1989).

The proportion of each habitat type within the study area was determined. After determining the proportion of each habitat category, the above hypothesis was tested.

The observed occurrence of wolves was compared with the "expected" occurrence of wolves for each habitat category. The analysis was performed by using the statistical package **PREFER** (Prasad and Gupta 1992) based on the utilization-availability technique developed by Neu *et al.* (1974) and clarified further by Byers *et al.* (1984). The expected proportional use lies in the range of Bonferroni confidence intervals if the habitat is utilized more than expected by chance. If the expected proportional use lies beyond the Bonferroni confidence intervals i.e., its value is larger than the lower as well the upper confidence limit, the habitat is utilized less than expected. On the other hand, if the expected proportional usage is greater than the lower confidence limit of Bonferroni confidence interval but lower than the upper confidence interval then the animals utilize the area in proportion to its availability.

The data collected from the hide as well as random observations around water holes were pooled into three seasons and Kruskal-Wallis one-way analysis of variance was done to compare seasonal use of waterholes by the wolves.

6.4 Results

The habitat utilization method is discussed in this chapter which is based on the technique given by Neu *et al.* (1974), Byers *et al.* (1984) and Griffith and Peek (1989).

Using the chi-square test it was found that for all three seasons there was significant ($P<0.05$) selection against utilization of the available habitats in proportion to occurrence (Table 6.1). Bonferroni confidence intervals were calculated to determine whether the various habitats were preferred or avoided (Tables 6.2-6.4 and Tables 6.6-6.8). A single asterik in the table means the habitat type was utilized less often than the proportion with which it occurred (0.05 level of significance) during that season. Two asteriks mean that the habitat type was utilized in equal proportion to its occurrence and three astriks mean that the habitat type was positively selected (0.05 level of significance) during that season.

During monsoon and winter seasons, the wolves utilized the grassland area more than expected by chance whereas the plantation and scrubland habitat types were utilized in proportion to availability. Grazing land was explored by the wolves less often than the proportion with which it occurred (Table 6.2 and 6.3).

During summer, the wolves utilized plantation and grassland habitat types more than expected by chance whereas utilization of grazing land was less than expected (Table 6.4). The scrubland habitat was used in proportion with which it occurred.

When the observations were grouped for the habitat types based on different time periods of the day (see data analysis), using the chi-square test it was found that for all three time intervals, there was significant selection ($P<0.05$) against utilization of the available habitats in proportion to occurrence (Table 6.5).

Table 6.1 The chi-square statistics with regards to seasonal selection of various habitat types by wolves (1991-1994)

Habitat Type	Monsoon			Winter			Summer		
	Observed	Expected	Chi	Observed	Expected	Chi	Observed	Expected	Chi
Grassland	77	58.58	5.79	46	49.92	0.31	42	56.50	3.72
Grazing land	62	55.39	0.79	52	47.19	0.49	42	53.42	2.44
Scrubland	15	25.21	4.13	26	21.48	0.95	30	24.31	1.33
Plantation	15	29.82	7.37	20	25.41	1.15	49	28.76	14.24
Total			18.08			2.90			21.73
Degrees of freedom			3			3			3
Significance level			p<0.05			p<0.50			p<0.001

Table 6.2 Simultaneous Bonferroni confidence intervals for habitat use by wolves during monsoon period (1991-1994)

Habitat Category	Total Area (ha)	Rel Area	Exp Usage	Obs Usage	Exp Prop Usage	Bonferroni Conf Intervals
Grassland	165.00	0.085	14.396	77	0.085	$0.360 \leq p \leq 0.551^{***}$
Grazing land	1378.13	0.711	120.243	62	0.711	$0.274 \leq p \leq 0.460^{*}$
Scrubland	257.81	0.133	22.494	15	0.133	$0.034 \leq p \leq 0.143^{**}$
Plantation	136.00	0.070	11.866	15	0.070	$0.034 \leq p \leq 0.143^{**}$
Total	1936.94		168.99	169		

* The habitat utilized less than expected
** The habitat utilized in relation to availability
*** The habitat utilized more than expected

Table 6.3 Simultaneous Bonferroni confidence intervals for habitat use by wolves during winter period (1991-1994)

Habitat Category	Total Area (ha)	Rel Area	Exp Usage	Obs Usage	Exp Prop Usage	Bonferroni Conf Intervals
Grassland	165.00	0.085	12.267	46	0.085	$0.222 \leq p \leq 0.417^{***}$
Grazing land	1378.13	0.711	102.456	52	0.711	$0.261 \leq p \leq 0.461^{*}$
Scrubland	257.81	0.133	19.167	26	0.133	$0.100 \leq p \leq 0.261^{**}$
Plantation	136.00	0.070	10.111	20	0.070	$0.067 \leq p \leq 0.211^{**}$
Total	1936.94		144.00	144		

* The habitat utilized less than expected
** The habitat utilized in relation to availability
*** The habitat utilized more than expected

Table 6.4 Simultaneous Bonferroni confidence intervals for habitat use by wolves during summer period (1991-1994)

Habitat Category	Total Area (ha)	Rel Area	Exp Usage	Obs Usage	Exp Prop Usage	Bonferroni Conf Intervals
Grassland	165.00	0.085	13.885	42	0.085	$0.172 \leq p \leq 0.343^{***}$
Grazing land	1378.13	0.711	115.974	42	0.711	$0.172 \leq p \leq 0.343^{*}$
Scrubland	257.81	0.133	21.696	30	0.133	$0.108 \leq p \leq 0.260^{**}$
Plantation	136.00	0.070	11.445	49	0.070	$0.211 \leq p \leq 0.390^{***}$
Total	1936.94		163.00	163		

* The habitat utilized less than expected
** The habitat utilized in relation to availability
*** The habitat utilized more than expected

Table 6.5 The chi-square statistics with regards to seasonal selection of various habitat types during different hours of the day (1991-1994)

Habitat Type	06:00-10:20 H			10:20-14:40 H			14:40-19:00 H		
	Observed	Expected	Chi	Observed	Expected	Chi	Observed	Expected	Chi
Grassland	71	53.12	6.02	20	40.89	10.67	69	66.00	0.14
Grazing land	49	51.79	0.15	27	39.86	4.15	80	64.35	3.81
Scrubland	22	27.22	1.00	31	20.95	4.82	29	33.82	0.69
Plantation	23	32.87	2.96	49	25.30	22.21	27	40.84	4.69
Total			10.13			41.85			9.33
Degrees of freedom			3			3			3
Significance level			p<0.05			p<0.001			p<0.05

During morning and evening hours, the wolves preferred grassland and plantation habitat types thus rejecting the null hypothesis for these habitat types (Table 6.6 and 6.8). The null hypothesis is accepted for scrubland since it was used in proportion to its availability or occurrence. Grazing land was avoided by the wolves. During the afternoon hours, scrubland and plantation habitat types were preferred by the wolves, grassland type was used in proportion to availibility (Table 6.7) whereas grazing land was used less than expected. In a nut shell, it is concluded that scrubland and plantation habitat types were preferred by the wolves (rejecting the null hypothesis) during afternoon hours when the atmospheric temperature is generally high, with data lacking to reject the null hypothesis for grassland.

6.4.1 Rendezvous sites

After leaving the natal den, the pups move to a secluded, sheltered area called rendezvous site. A rendezvous site is a meeting place of different members of a pack which is meant basically for pup rearing. Rendezvous sites have also been referred as "loafing spots" or resting sites (Young 1944). At Nannaj, the pups remain at these sites till the second or third week of March when they begin moving with the pack. Till this time the adults i.e., parents and/or alloparents hunt and bring food for the growing pups.

Spearman rank correlation was performed on habitat variables which have been used to find out selecting of the rendezvous sites by the wolves. The matrix of

Table 6.6 Simultaneous Bonferroni confidence intervals for habitat use by wolves between 06:00-10:20 H (1991-1994)

Habitat Category	Total Area (ha)	Rel Area	Exp Usage	Obs Usage	Exp Prop Usage	Bonferroni Conf Intervals
Grassland	165.00	0.085	14.039	71	0.085	$0.334 \leq p \leq 0.527^{***}$
Grazing land	1378.13	0.711	117.432	49	0.711	$0.208 \leq p \leq 0.386^{*}$
Scrubland	257.81	0.133	21.967	22	0.133	$0.067 \leq p \leq 0.199^{**}$
Plantation	136.00	0.070	11.562	23	0.070	$0.072 \leq p \leq 0.207^{***}$
Total	1936.94		165.00	165		

* The habitat utilized less than expected
** The habitat utilized in relation to availability
*** The habitat utilized more than expected

Table 6.7 Simultaneous Bonferroni confidence intervals for habitat use by wolves between 10:20-14:40 H (1991-1994)

Habitat Category	Total Area (ha)	Rel Area	Exp Usage	Obs Usage	Exp Prop Usage	Bonferroni Conf Intervals
Grassland	165.00	0.085	10.795	20	0.085	$0.077 \leq p \leq 0.238^{**}$
Grazing land	1378.13	0.711	90.424	27	0.711	$0.122 \leq p \leq 0.303^{*}$
Scrubland	257.81	0.133	16.891	31	0.133	$0.149 \leq p \leq 0.339^{***}$
Plantation	136.00	0.070	8.890	49	0.070	$0.278 \leq p \leq 0.494^{***}$
Total	1936.94		127.00	127		

* The habitat utilized less than expected
** The habitat utilized in relation to availability
*** The habitat utilized more than expected

Table 6.8 Simultaneous Bonferroni confidence intervals for habitat use by wolves between 14:40-19:00 H (1991-1994)

Habitat Category	Total Area (ha)	Rel Area	Exp Usage	Obs Usage	Exp Prop Usage	Bonferroni Conf Intervals
Grassland	165.00	0.085	17.390	69	0.085	$0.254 \leq p \leq 0.419^{***}$
Grazing land	1378.13	0.711	145.669	80	0.711	$0.305 \leq p \leq 0.475^{*}$
Scrubland	257.81	0.133	27.211	29	0.133	$0.081 \leq p \leq 0.202^{**}$
Plantation	136.00	0.072	14.731	27	0.072	$0.073 \leq p \leq 0.191^{***}$
Total	1936.94		205.00	205		

* The habitat utilized less than expected
** The habitat utilized in relation to availability
*** The habitat utilized more than expected

correlation coefficients (Table 6.9) reveals that most of these variables are intercorrelated (positive or negative, mostly positive relationship) and significant at $P<0.05$ and $P<0.001$ levels.

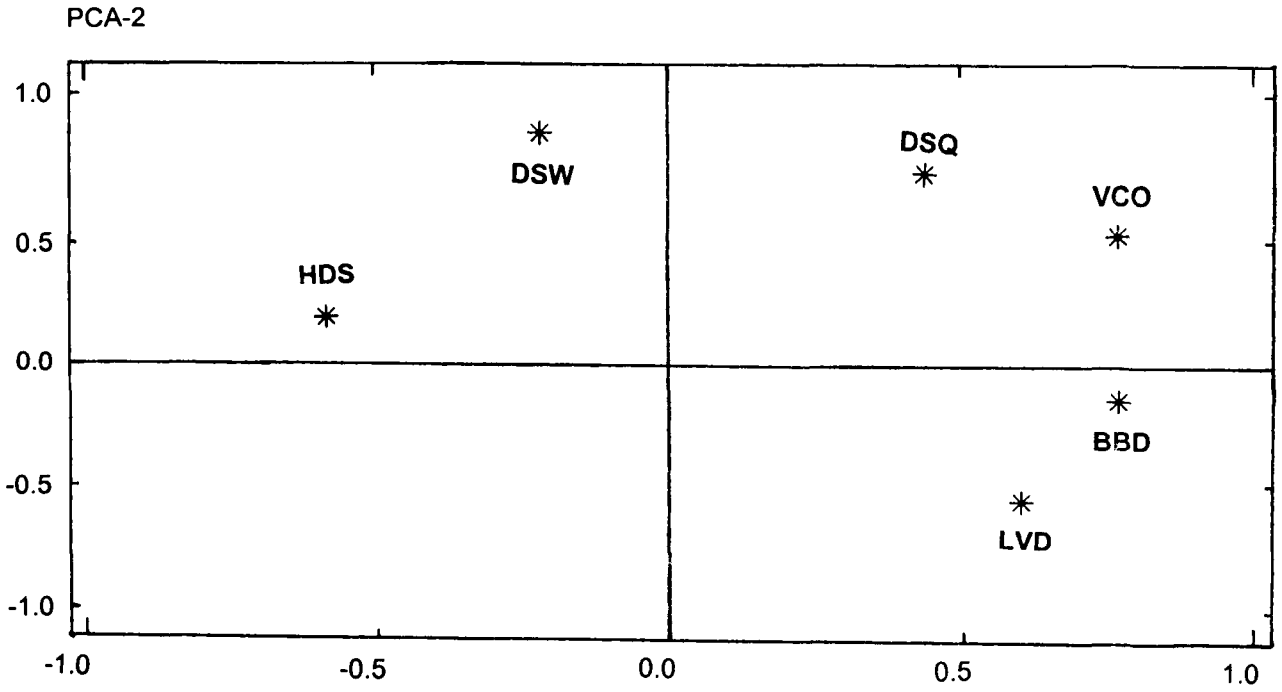
The first principal axis in Fig. 6.1 and 6.2 is so oriented so as to make the variance of the first-principal-component loading as great as possible; these are the scores of the parameters (i.e., the coordinates of the data points measured along the x-axis) (the first principal axis). In other words, this means that the axis is oriented in such a way that when the data are projected onto it, they have the greatest possible spread.

The second principal axis is so oriented as to make the variance of the second-principal-component loadings (the values of y1, y2, ...y6) as great as possible, which is possible only if the second axis is perpendicular to the first axis. The first and second-principal-component scores (the x and y points) are uncorrelated and have zero covariance.

PCA retained only three factors out of six which explained most of the variability of data.

The first three principal components contributed for 77% of the cumulative total variance (Table 6.10). The first component accounted for 35.25% of the total variance. Most habitat variables were positively correlated with the first component

Fig. 6.1 Plot of habitat variables on Principal Component Axis-1 and 2



HDS=Human Disturbance
VCO=Vegetation Cover
BBD=Density of Blackbuck
LVD=Density of livestock
DSW=Distance to water source
DSQ=Distance to stone quarry

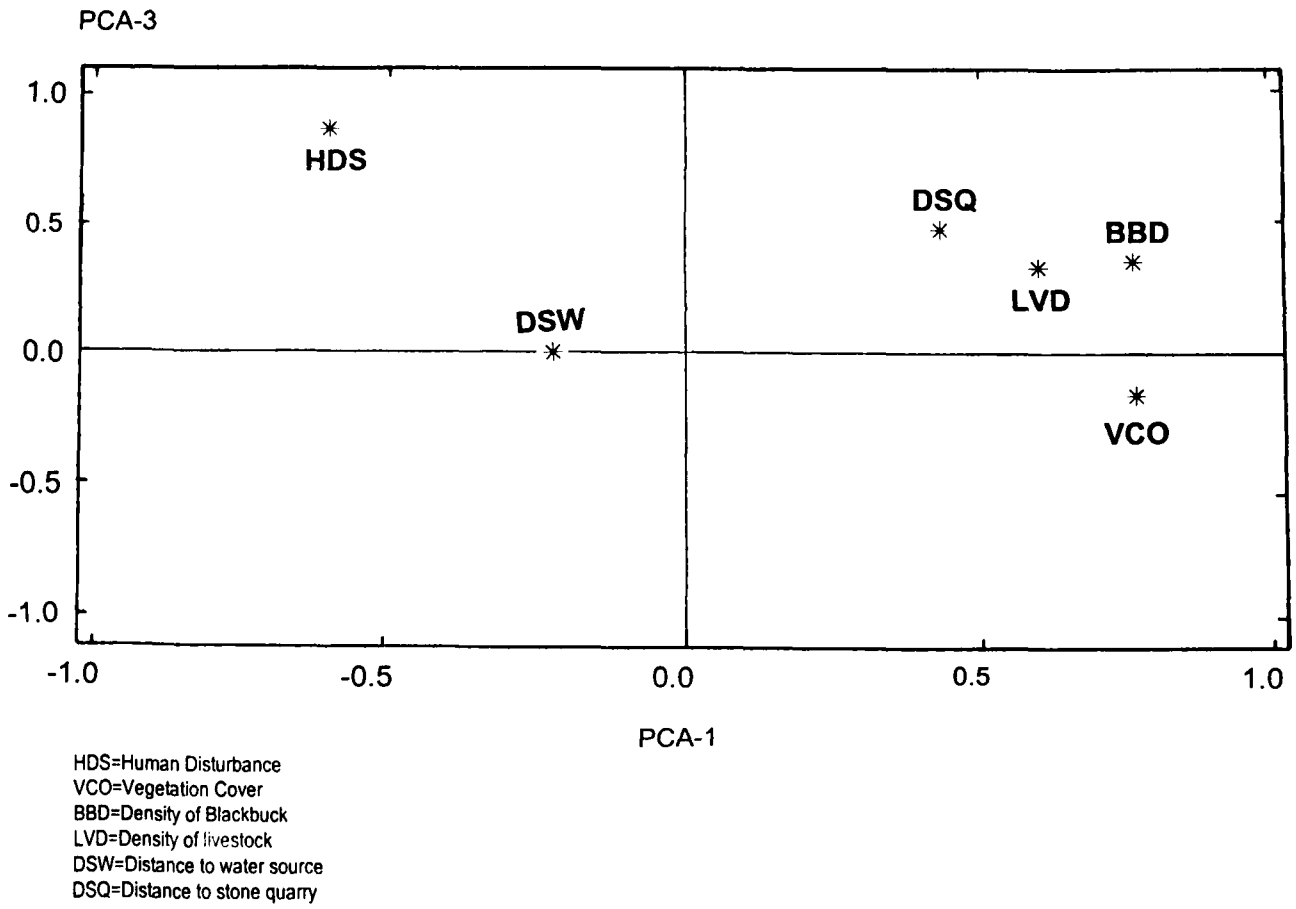


Fig. 6.2 Plot of habitat variables on Principal Component Axis-1 and 3

Table 6.9 A matrix of Spearman rank correlation coefficients between different habitat parameters

Habitat variables	HDS	VCO	BBD	LVD	DSW	DSQ
Human disturbance	1.000	-0.505**	-0.457**	-0.184	0.106	0.119
Vegetative cover	-0.505**	1.000	0.591**	0.275*	0.119	0.267*
Blackbuck density	-0.457**	0.591**	1.000	0.365*	-0.301*	0.262
Livestock density	-0.184	0.275*	0.365*	1.000	-0.335*	-0.062
Dist. to water source	0.106	0.119	-0.301*	-0.335*	1.000	0.252
Dist. to stone quarry	0.119	0.267*	0.262	-0.062	0.252	1.000

* Significant at $P<0.05$
** Significant at $P<0.001$

Table 6. 10 Principal Component Analysis of rendezvous sites variables showing component loadings

VARIABLES	COMPONENT LOADINGS		
	1	**2**	**3**
Human disturbance	-0.596	0.061	0.764
Vegetative Cover	0.773	0.466	-0.154
Blackbuck density	0.754	-0.154	0.284
Livestock density	0.584	-0.529	0.276
Distance to water source	-0.245	0.786	-0.075
Distance to stone quarry	0.440	0.668	0.410
Variance explained by component loading	2.12	1.59	0.94
Percent of total variance explained	35.25	26.49	15.61
Cumulative	35.25	61.74	77.34

except for disturbance due to the presence of human beings and distance from water source. The highest correlations were with vegetative cover and the density of Blackbuck. High values on the first component correspond to habitat with high vegetative cover and high Blackbuck density. The first component hence represents, with increasing values, a trend of selecting those patches from clear and "open" grassland plains to shrubland.

The second component accounted for an additional 26.49% of the total variance (Table 6.10). This component was negatively correlated with the density of Blackbuck and livestock. The remaining parameters were positively correlated with the second component. High values on the second component loading correspond to longer distances to stone quarries and water sources from the rendezvous sites.

The third component loading accounted for 15.61% of the total cumulative variance (i.e., 77.34%). Disturbance due to humans, density of Blackbuck, density of livestock and distance to stone quarries showed positive correlation with the third component.

Fig. 6.1 depicts the plotting of the first two component loadings on Principal Component Axis-1 (PCA-1) and PCA-2 axes. The wolves preferred rendezvous sites in the patches having maximum vegetation cover and density of Blackbuck, since they are loaded high on PCA-1. Distance to water source and distance to stone quarries were loaded high on the PCA-2 and thus selected by wolves.

In Fig. 6.2, the third component loading (PCA-3) is plotted against first component loading (PCA-1). The wolves preferred rendezvous sites in those areas of the Sanctuary which had maximum vegetation cover, high Blackbuck density and also high density of livestock since their locations are high on PCA-1. On PCA-3, human disturbance and distance to stone quarries were the factors to select or reject potential rendezvous sites by the wolves.

6.4.2 Characteristics of rendezvous sites

Each rendezvous site (RS) usually located in scrubland had good vegetation cover. The rendezvous sites had a characteristic odour which is due to the droppings and sometimes because of the presence of kills.

Each rendezvous site had a close proximity to water source. All such sites were located more or less in an "open" or relatively flat area except for the two which were located in a depression in grassland plots (S1 and M2) and were used for less than a week.

The first two rendezvous sites were closer to the den latest in use than the sites which were used later. The distance between the rendezvous sites varied from 140-500 metres **(X=220)**.

The sites were located in relation to the boundary of the territory and they correlated positively with the prey density as in the case of the dens.

The pack continued to use a particular site for two to three weeks if they were not exposed to disturbance in that area. After the pack shifted to another site, it took at least a week to locate the new site.

6.4.3 Number and distribution of resting sites

During 1992, the wolves used two rendezvous sites, both located in the grazing land outside the protected plots of the Sanctuary (Fig. 6.3). The first rendezvous site was located in an open and relatively flat area compared to the second rendezvous site. A Babool tree was present at this site and distance to the water source was less than a kilometer. The pups restricted their activities to this site till about March 10 when they shifted to the second rendezvous site 0.3 km away. The Babool tree provided excellent shade to the pups in summer. The average distance from water source and the two rendezvous sites was 0.8 km.

The second rendezvous site was located on a well elevated area along a mild slope. The pups remained at this site for another week and moved to a third site in the grassland plot (S2). They were observed for few days irregularly at this new site and then started moving with the parents. Rendezvous site-2 was located under a White Acacia tree. *Cassia auriculata* was predominantly present in this patch.

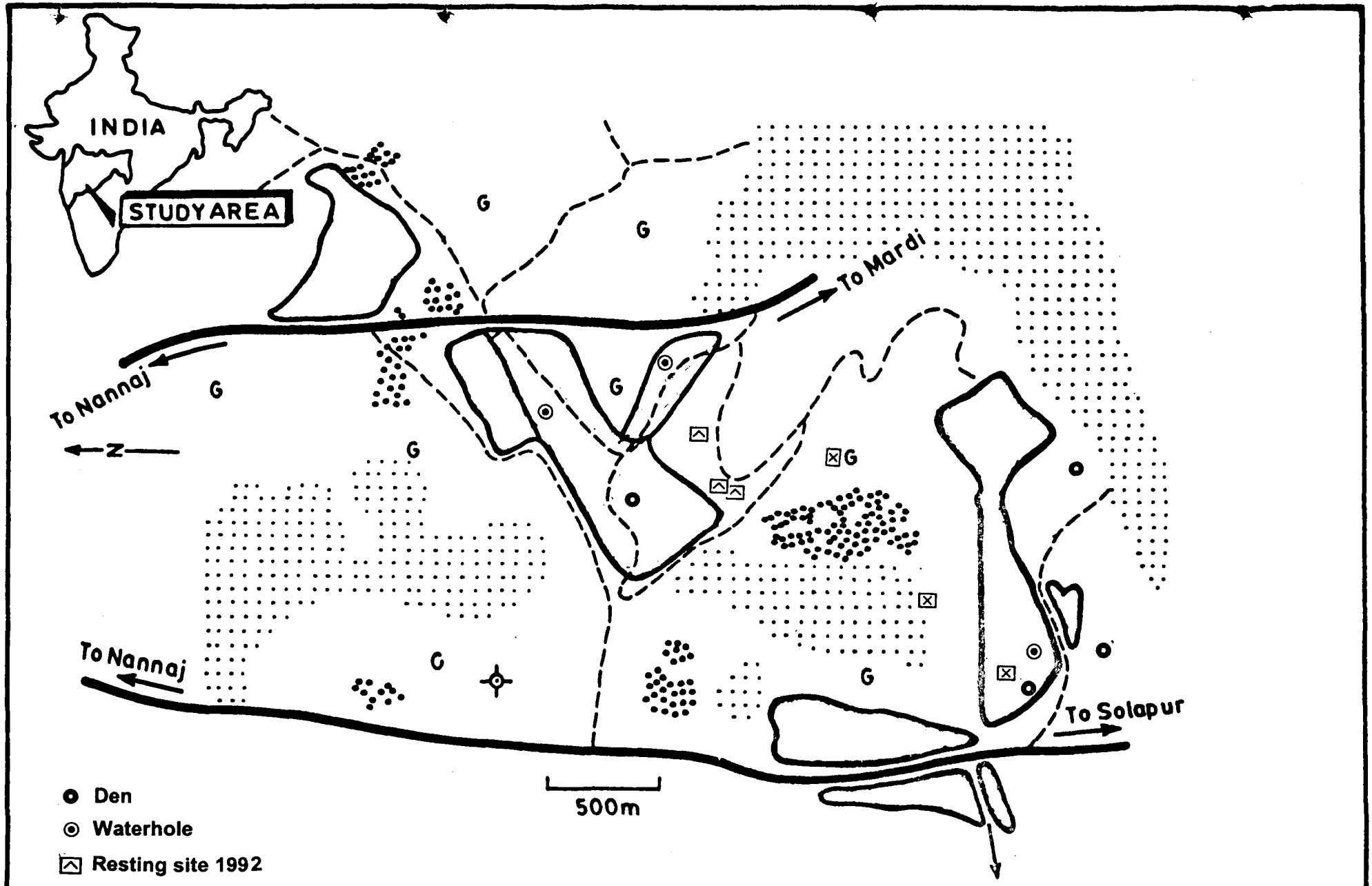


Fig. 6.3. Study site showing waterholes, rendezvous sites and dens used by wolves

The particular period of occupying a particular site, the den used last during both of the breeding years and the various relationships of dens and rendezvous sites with water source and core area are summarized in Table 6.11.

In 1994, the pups moved between four rendezvous sites. The first rendezvous site was located in a grassland plot near den #5 (Fig. 6.3). This year, one of the rendezvous sites (site-2) selected by the pack was located at the same place (Fig. 6.3) which was selected during 1992 (rendezvous site-1) . During his study on wolves in Algonquin Park, Joslin (1967) has also reported that if undisturbed they use the same rendezvous site for consecutive years.

The third and fourth rendezvous sites were located in the grazing land closer to the grassland plot (M2). The first RS was closer (0.13 km) to the natal den (i.e., den #5) than the second (1.7 km). The average distance between the above rendezvous sites was 0.9 km (S.D.=0.39).

The wolves used patches of shrubland with few scattered *Acacia* trees as rendezvous sites in both the years (i.e., 1992 and 1994). Percent vegetative cover at the rendezvous sites varied from 20-30% and wolf use was maximum in the above range of vegetative cover (Figs. 6.4 and 6.5). Selection of these areas was probably due to the following reasons:

1. Less human disturbance
2. Optimum vegetation cover

Fig. 6.4 Use of rendezvous sites by wolves (1992)

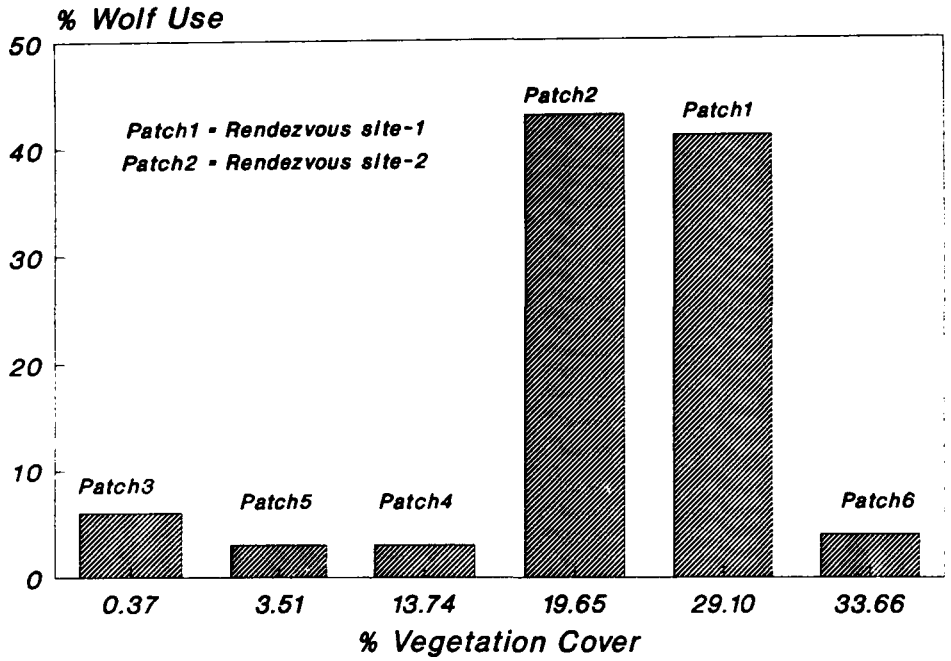


Fig. 6.5 Use of rendezvous sites by wolves (1994)

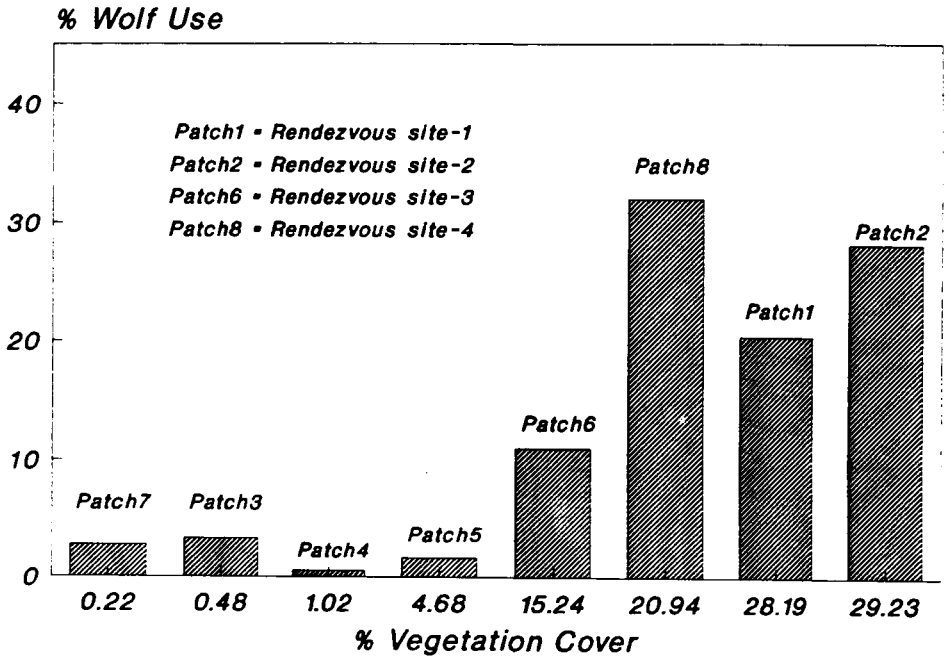
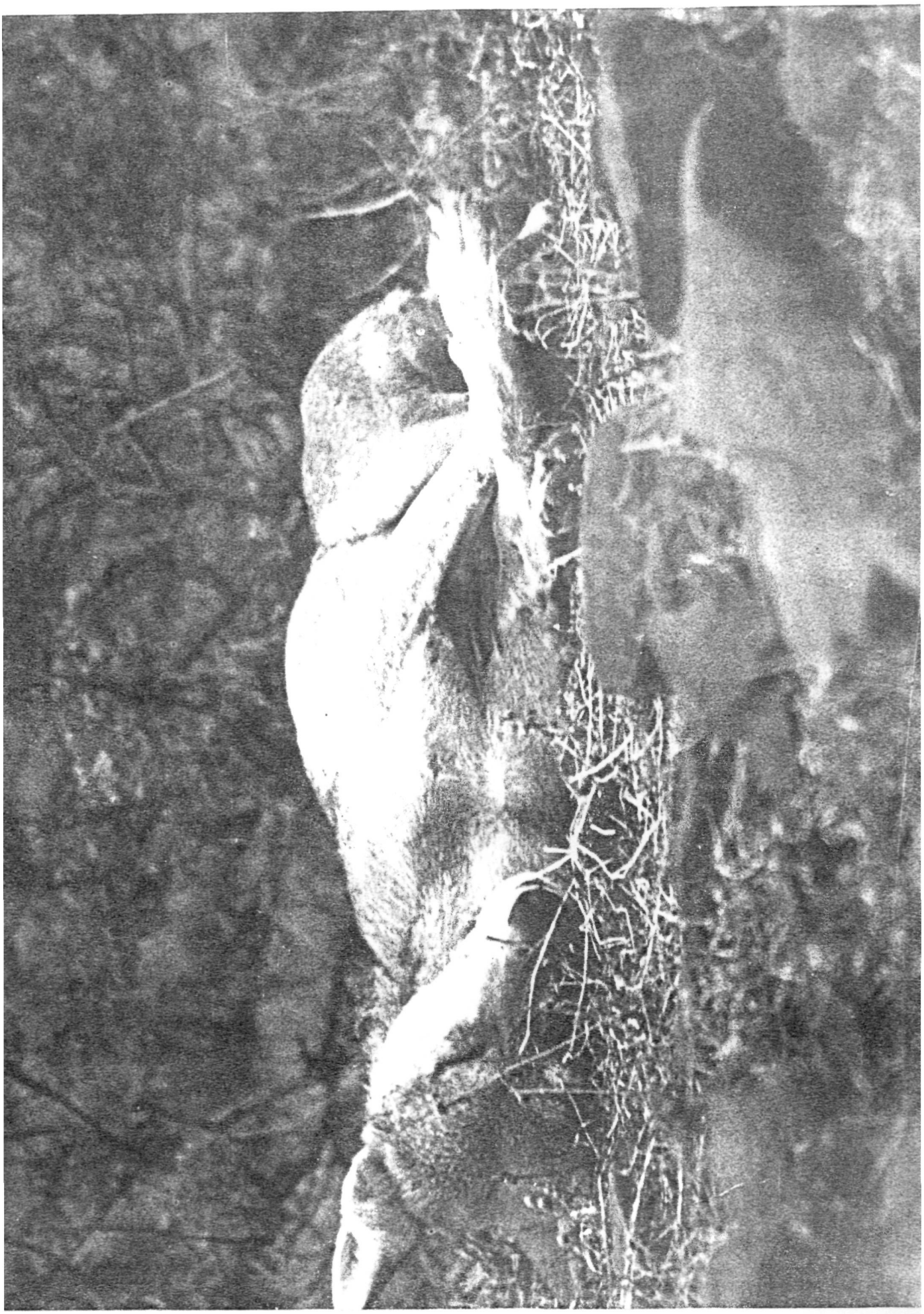


Table 6.11 Realationships between dens, rendezvous sites, water source and core area

DENS				RENDEZVOUS SITES							
				I Rendezvous site				II Rendezvous site			
Period Occupied	Periods during which dens were vacated	Distance from core area	Distance from water source	Period occupied	Dist. from Den	Dist. from Core area	Dist. from water source	Period occupied	Dist. from Den	Dist. from Core area	Dist. from water source
Dec 26± 1991 to Feb. 6, 1992	Feb. 2 to Feb. 6	2.47 km	2.88 km	Feb. 7± to Mar 10	1.8 km	0.60 km	0.88 km	Mar. 15± to Mar. 18	2.18 km	0.45 km	0.70 km
Jan 4± 1994 to Feb. 20, 1994	Feb. 18 to Feb. 23	2.22 km	0.18 km	Feb.19± to Feb.28	0.13 km	2.12 km	0.15 km	Mar. 1± to Mar. 9	1.73 km	0.55 km	0.80 km

Fig. 6.6 Alpha male lying up at a resting site.



6.4.4 Resting sites

The resting sites were located in the shrubland, sparsely wooded grassland, grazing land and plantation habitats.

The use of resting sites change according to the seasons for instance, the wolves used low lying areas for resting during winter mornings probably to avoid the cool breeze, and they used slightly elevated areas during summer months to get the cool breeze blowing in the morning. During day time the wolves mostly used to move into the plantation plots in the Sanctuary. The pack members dug out the surface 14-16 cm deep to expose the moist underneath where they used to curl up or lie down (Fig. 6.6) to spend the hot hours of the day.

The wolves were quite sensitive to disturbance at the resting or rendezvous sites. This was observed during 1992 when the wolves abandoned the first rendezvous site located in the grazing land. Disturbance has been discussed in another chapter on breeding biology.

6.4.5 Use of waterholes

The wolves were found to visit one of the waterholes located in S1 plot (Fig. 6.7) more frequently than the other two. The frequency of sighting of wolves at waterholes was found to be higher during summer and winter than monsoon. During summer, the wolves used to wade in the water.

Whenever the pack was spotted approaching towards a waterhole, the pups were the first to arrive and the adult members were always scared coming to a waterhole and reached last. The number of visits to the waterholes per day also increased during summer than winter or monsoon.

There was a seasonal difference in waterhole usage (Kruskal-Wallis test, H = 8.323, P=0.016) by wolves during 1992 and no seasonal difference (Kruskal-Wallis test, H = 3.880, P=0.144) during 1993. In 1993 only two wolves were left in the Nannaj Pack and may have been using some other water source outside thereby lowering the frequency of sightings during summer around waterholes in the Sanctuary plots.

6.5 Discussion

The use of space is an important aspect of the behavioural ecology of a species since it underpins the optimization of resource use (Barton *et al.* 1992). In order to develop an effective conservation strategy for protecting a species, it is often essential to know its detailed habitat requirements.

Some of the habitat patches, for instance, scrubland and plantation, are critical for wolves during summer because they provide them shade and shelter in this period when the environmental conditions are harsh and the air temperature is high. It is therefore, essential to maintain these patches and provide management input to them on regular basis.

Fig. 6.7 Artificial waterhole usually frequented by wolves

Habitat quality can be defined as the suitability of an area to support a reproducing population of a given species or a group of species. Prey and water availability might be important factors determining the quality and consequently the utilization of certain habitat types. In other words, a major factor that could influence the quality of habitat types is prey availability which in turn is a function not only of absolute prey density but also of various habitat factors influencing the accessibility of prey and time and energy needed to capture prey in different habitat types.

Everyday the wolves were found to be on the move during morning hours generally between 06:00 and 09:00 H, after which they used to retire. During afternoon hours they were observed only at the waterholes. With the decrease in air temperature in the evening hours, the wolves left their resting sites and again moved in the open grassland or grazing land for hunting. Most of the sightings during afternoon hours were either in or around the plantations.

The first and second rendezvous sites are usually closer to the natal den because if there is any potential hazard to the pups, the latter could go into the den with ease.

The use of rendezvous sites having 20-30% vegetative cover (Fig. 6.4 and 6.5) was related directly to the human disturbance factor which was found to be minimum at these sites than the shrubland patches with higher cover.

Usually the wolves frequented one waterhole located in S1 plot because of disturbance at the other two. One waterhole located in M2 plot was very close to road and usually occupied by people or by graziers who brought their livestock there for water.

The study reveals that the marginal habitats viz., scrubland and plantations are of paramount importance for the survival of the wolf in the plains of India. These habitat types therefore, need to be given special attention by the Sanctuary managers.

The wolves used those sites where the vegetative cover predominantly comprised of *Cassia auriculata* having some *Acacia leucophloea* and/or *Acacia nilotica* trees. They were not seen in pure *Cassia auriculata* patches. The reason of selecting the former patches is shade provided by these trees.

It was found that during both the breeding years, selection of rendezvous sites depended upon the availability of the tree species for shade and proximity to a water source. Even if there was sufficient shrub cover but no trees, wolves did not use such an area as a rendezvous site. On the contrary, they used a particular area as rendezvous site if a shade tree was present even if shrub cover was low. The other major factor contributing to selecting an area was the magnitude of human disturbance.

CHAPTER SEVEN

PREDATION ON BLACKBUCK

7.1 Introduction

Predation by wolves on wild ungulates has perhaps been the most widely studied aspect of their ecology in the world. Studies of wolves and their food habits have provided conclusive evidence that wolves depend primarily on hoofed mammals for their sustenance (Gunson 1995). The wolf's diet is overwhelmingly composed of these large mammals.

In North America, wolves depend upon ungulates for food in the winter and supplement this with smaller mammals or alternate prey species during spring and fall (Mech 1970, Pimlott 1975). In areas, where smaller mammals are not so abundant, ungulates usually account for more than 90 percent of the biomass consumed by wolves (Carbyn 1974, Fritts and Mech 1981, Holleman and Stephenson 1981).

The wolves are impulsive predators which start hunting only when they are driven by hunger. They consur as much of food as they can when it is available.

The only long-term study ever conducted on a large mammal predator-prey system in the world is the study of wolves and Moose in Isle Royale, Michigan (Mech 1970). The study started in the late fifties on this small 544 km² island is still continuing.

In this chapter, I describe the hunting methods of the wolves, kill/carcass consumption, spatial distribution of kills in different habitats, predator avoidance or antipredator behaviour of the prey. I also give a brief account of the impact of wolf predation on the Blackbuck population. An attempt is made to accumulate or secure the first quantitative data on the degree of predation. A study of the food habits is described in this chapter.

7.2 Methods

7.2.1 Identification of Kills

In my study area, both wolf and pie-dogs are predators of Blackbuck. To study the food habits of wolves, I had to identify their kills. The prey was confirmed having not been killed by dogs based on the following criteria:

1) If no evidence of struggle by the prey, blood stains, broken vegetation around kill was found, the animal was classified as to have died of natural death.

2) There was no dog seen in the area for half an hour after the kill was located.

3) The pattern of feeding by wolves and dogs was different. The dogs feed quite haphazardly (Fig. 7.1), whereas the wolves have preference for particular organs or parts such as viscera (Fig.7.2a) and consume them first and eat all parts except for few bones and skull (Fig. 7.2b). With some experience, I could distinguish the kills of two canids. But, all those kills where the real culprit was difficult to identify were discarded from analysis.

Fig 7.1 Blackbuck kill which has been eaten by dogs haphazardly

Fig 7.2a Wolves usually consume viscera first by removing the digestive tract of Blackbuck

Fig 7.2b Blackbuck consumed by the wolves completely

The crows *Corvus* spp. and raptors such as Pariah kite *Milvus migrans* helped to locate wolves on kills as they start hovering above and around the kills. Sometimes stray dogs were observed moving around the kills restlessly making me suspect the presence of kill in the area. It was very easy to locate wolves on kill on such occassions.

G-test (Sokal and Rohlf 1981) was used to compare the distribution of kills in different habitat types. Since the areas of different habitat types were different and unequal, so it was imperative to perform this test before making generalizations from the kill distribution data in different habitats. A basic programme (PREFER) was used in conjunction with the G-test to find out the preference or avoidance of a particular habitat (Prasad and Gupta 1992).

With the passage of time and experience, it was not difficult to locate the pack on kills. Once the pack was spotted at a kill, continuous attention was paid to it until it moved away from the kill. Data was collected on sex and age of the kill, biomass left unconsumed, distance of the kill from the protected area where the animal was killed, distance of the kill from the den and distance to nearest vegetation from the kill. The terrain and the vegetation of the site were also recorded.

The weight of each kill left unconsumed and the number of wolves that were known to have fed on the kill with certainty were recorded to compute the mean consumption rate of wolves. It was not always possible to know exactly as to how many wolves were feeding on the carcass particularly at longer distances. I could overcome this problem during 1993 when four and ultimately only two wolves (Alpha pair) were left in the territory. It was possible to locate the pack of four and two wolves (Alpha pair) 11 times on the kills consecutively, presuming that there was no kill besides the observed 11 kills made by wolves. Data on kills from 11 such kills was used for calculation of the average consumption by wolves and also food consumption per day per wolf.

Pups refer to the individuals less than six months of age, subadults or juveniles as 6-7 months old individuals, yearlings as 1-2 years and adults two and more than two years of age. However, it is extremely difficult to distinguish yearlings from adults in the field unless they are observed from very close quarters.

The average weight of an adult male Blackbuck has been reported as 39 kg, of female 28 kg, subadult male 28 kg, subadult female 20 kg, yearlings 16 kg and fawn 5.5 kg (Ranjitsinh 1989). Since the Blackbuck become weak during summer and very weak during drought period, I considered the weight of an adult male Blackbuck (M1 and M2) to be 36 kg, of adult female 25 kg, subadult male (M3) was considered 28 kg, subadult females, yearlings, subadult males (M4) 10 kg, and fawn 5.5 kg.

Mann-Whitney U Statistic (STATA 5.0, 1997) was used to test differential predation rates of wolves on male and female Blackbuck. Kruskal-Wallis one-way analysis of variance (SYSTAT 4.0, 1988)) was used for seasonal variation of Blackbuck kills.

7.3 Results

The wolf pack was frequently spotted at a kill between 06:00-07:00 H, rarely after 07:30 H mainly due to the disturbance by people moving in the area.

7.3.1 Hunting Strategy

The wolves are long-legged and adapted for cursorial mode of life and probably rank second among large carnivores after cats that are able to hunt sufficiently large prey. Since the wolves prey on animals larger than their own size, it is likely that they could get injuries from their prey. They are known to have been killed by Moose *Alces alces* (Ballard *et al.* 1987), Musk-oxen *Ovibus moschatus* (Savile and Oliver 1964; Pasitschniak-Arts *et al.* 1988), and White-tailed deer (Nelson and Mech 1985). The major prey species of Indian Wolf at Nannaj is the Blackbuck. The alternate or secondary prey species include hares namely, Blacknaped hare *Lepus nigricollis* and some unidentified rodents. Thus the predator-prey system was very low in prey diversity. It is hard for wolves to kill Blackbuck since the latter are very swift. The wolves were found to employ the following hunting strategies:

a) Driving a group or single Blackbuck towards rest of the hunting members (that had kept themselves concealed) and attack suddenly or start a chase depending on circumstances.

b) Chasing animals down a slope for a short distance but not running for long time if the wolves could not maintain pace with the Blackbuck, i.e., the wolves always used to stop chase if the prey kept a long distance from the predator(s) during the chase. Long pursuit of a healthy Blackbuck was avoided because the chances of success are very low.

c) Locating a sick animal or an injured individual from a herd of Blackbuck and chasing it. In much cases, the chase always continued for long duration and mostly culminated in successfuly wearing down a Blackbuck. Whenever fawns of the Blackbuck and hares were chased, wolves usually succeeded in catching them.

Both olfactory and visual communication senses are highly developed in wolves. For prey, the wolf depends on its strong smelling power in the forested areas, and sight in the "open" habitat (Mech 1970). It was found that hunting always depended on the terrain and circumstances. This refers to behaviour of the pack members. For instance, chasing the prey upon judging its running speed, ambushing an individual in a wooded patch. Sometimes a resting Blackbuck or a territorial adult male was ambushed by wolves by going through small bushes and shrubs. On some occasions, I saw wolves chasing a group of healthy Blackbuck, probably without any intention of killing them.

Following, is the description of two adult male Blackbuck observed while being hunted by the wolves and some interesting predator-prey interactions:-
In October 1991, four wolves approached a mixed herd of the Blackbuck and all the males of the herd came to the front with their heads pointing towards the approaching wolves. One of the wolves was hit by a male Blackbuck and thrown away. All the wolves left immediately.

In June 1992, two wolves chased a Blackbuck doe with a fawn and the wolves succeeded in catching the fawn. The doe charged the wolf and attempted twice to hit one of the wolves on the rump. The second individual was very far from the Wolf-Blackbuck encounter spot. The wolf did not attempt to make any effort to attack the Blackbuck. It was not possible to identify the wolves as adults or juveniles.

On another occasion in May 1993, an injured male Blackbuck was resting in an area when a single wolf was observed to ambush the Blackbuck from a ditch/depression. The area was heavily dug due to quarrying. The wolf managed to go close to the Blackbuck without being noticed and attempted to bite the buck from the hind quarters. The wolf was hit by the Blackbuck with horns. The wolf got up after one and half minutes and went straight to a water hole.

On July 3, 1992, a pack of seven wolves chased a group of Blackbuck (14 individuals) at 14:00 H. The wolves selected an injured male present in the group

and continued chasing it for more than 1 km in an arc. All the seven wolves chased the target animal. During the chase, the alpha male was close enough to attack the buck on the rump. I was observing this hunt from a hut at 300 m distance. The packmates joined the alpha male immediately. One wolf started biting the Blackbuck on the snout immediately after joining the alpha male and others on the rump and viscera.

Out of seven wolves, four started chasing another group of Blackbuck soon after the first injured Blackbuck was brought down. The chase was abandoned after one and half minutes.

One wolf left the area and returned with another five wolves (juveniles) to the kill site after five minutes. By 14:40 H, the pack had completely finished the kill.

The preference of wolves to different parts of Blackbuck was found to be in the following order:

Visceral parts > Rump > Limbs and neck region > Head region

The digestive tract was always dragged few meters from the kill by the wolves. Once a wolf was seen carrying along the rumen of the Blackbuck. The wolves used to urinate repeatedly around kills after finishing them off and they used to return to the kill sites frequently and chew the remaining bones.

On July 16, 1993 (06:05 H), the alpha male and alpha female were observed killing a territorial buck. The male was sitting at its midden near a short bush. It was not observed how the wolves approached and went close to the buck, but accidentaly at 06:10 H, I found the buck struggling with the wolves that had caught hold of it. The downed buck was observed four times making its efforts to get up and run away but was again overpowered by the wolves. The Blackbuck went 20 m away from its midden during the course of struggle with wolves. One wolf grabbed the animal from the snout and the other eviscerated it. Grabbing the prey from its snout may result in asphyxia. After the buck died in 8-10 minutes, it was further dragged by the wolves into the open area. The Blackbuck died of repeated biting resulting in multiple wounds and evisceration. The struggling between the Blackbuck and the wolves was confined to a small patch of about 10 X 30 m.

The wolves fed on the kill till 07:50 H and left the carcass without making any effort to conceal it. All predation attempts by wolves on adult male Blackbuck consisted of attacking initially from the rear. Once the prey was down and weakened due to the initial attack, some individuals started biting on the front.

Similarly on June 15, 1994 a territorial male of the Great Indian Bustard was killed by a pack of eight wolves (Kumar 1995).

Some Blackbuck were injured while escaping from the nooses of the snares (Fig. 7.3) put up by irate farmers for Blackbuck that come to raid crops during nights. The

animals that get entangled in the snares injure their tarsi severly and are unable to run. They easily fall prey to hunting wolves (Fig. 7.4). Twice such animals were seen being hunted by the pack during the day light hours.

The fawns were hunted when they used to flush from grassland or scrubland patches by the wolves. Wolves were vigilant on females with neonates. One or two wolves used to approach towards a doe with neonate and spring into chase.

7.3.2 Prey Selection

Wolves are capable of hunting and killing prey species much bigger than their own body size. The pack hunters like the Wolf and Cape Hunting Dog *Lyacon pictus* are largely dependent on whatever large ungulates, e.g., Moose, deer (*Odocoileus*), Caribou (*Rangifer*), Sheep (*Ovis*), and antelopes such as Gazelle (*Gazella*) and Blackbuck, are found in their respective habitats (Estes and Goddard 1967; Kruuk and Turner 1967; van Lawick and van Lawick-Goodall 1971; Mech 1970; Jhala 1993; Kumar *et al.* 1997). But the diet, at least for the wolf is supplemented occasionally with lagomorphs and small rodents.

Out of 11 observations of different age groups of Blackbuck chased by wolves, the latter singled out a sick or an injured animal (n=7). The chase never continued for long when wolves know their limits perhaps by judging the speed of the animal(s) being chased.

Fig. 7.3 Snares with nooses used by farmers to kill Blackbuck

Fig 7.4 The Blackbucks are injured after escaping from snares and fall prey to wolves. here the arrow pointing out a deep cut in the hind limb of a male Blackbuck

The wolves used to keep a strict vigilence on the movement of Blackbuck herd with fawns. When a Blackbuck herd grazing in a grassland moves ahead leaving behind some of the fawns in the grass, these fawns were usually chased by wolves (n=18). Fourteen fawns were killed by the wolves on 18 occasions.

They also had a strong selection for male Blackbuck (See predation), especially territorial males, because of their reluctance to leave territories.

Out of 14 fawns of Blackbuck, ten were probably one or less than one day old (neonates) which were overcomed by wolves within a short distance (less than 100 m). The remaining four were chased for long distances before being killed. All the fawns were killed in open grasslands during the peak fawning season of Blackbuck i.e., September-October or February.

On all occasions, either a solitary or two wolves chased the fawn. After catching a fawn, the wolf always ran away carrying the fawn in the mouth. On one occasion, the second wolf struggled for nearly three minutes to get a share of food procured by the first wolf. Sometimes (n=6), the animals under observations went out of view while carrying fawn in the mouth.

7.3.3 Feeding habits and consumption rate

After a Blackbuck is killed, the wolves generally feed first on the visceral parts and the rump. Limbs and neck region were second in the preference order and skull and

head regions ranked last. The Nannaj Pack was rarely seen feeding on the kill after 07:30 H. After this time, the pack used to feed on the kill in quite a haste as if not going to leave the remaining biomass unconsumed. The young ones always used to leave the kill last. The digestive tract was always dragged few metres away from the kill site and not consumed. This has also been observed by Jhala (1991) in Velavadar.

Wolves are known to feed six times more than their normal food intake because of having distensible stomachs (Mech 1970). Based on my data on 11 consecutive kills, average consumption rate of wolves was found to be 3.68 kg/wolf/kill (S.E. 0.17). On an average, wolves made a kill every 3.65 days (S.E. 0.58, n=19, during November-December) and thus the everyday consumption rate was found to be 1 kg/wolf. Whereas during summer (May-June) inter-kill interval was of 2.1 (S.E. 0.7 days, n=10) days.

Consumption rate of wolf was not correlated with pack size (r_s=0.16, P=0.07). Although average food consumption was computed for the wolf, but there was a wide variation in pack size as well as biomass consumption of wolves.

The effect of kill-interval on biomass consumption per wolf was estimated by linear regression. The slope estimate was found to be 0.321 (s.e. 0.061) and the ratio of slope to its standard error is 5.30. The null hypothesis of a zero slope can be rejected because the probability of getting 5.30 t-value is less than one chance in a

thousand ($P < 0.001$) for this data set on periodicity in kill rate and biomass consumption.

The regression analysis reveals that average biomass consumption per wolf increases about 0.321 kg for every one percentage increase in the kill-interval (Fig. 7.5). Pearson correlation coefficient ($r=0.438$) shows that a one standard deviation unit increase in kill-interval results in a 0.438 standard deviation unit increase in biomass consumption. Besides carnivory, which was exhibited by and large by the Indian Wolf, it was frequently observed to feed on poultry waste near poultry farm at Akolakati, and fruits such as berries of *Zizyphus*. *Zizyphus* fruits were quite common in their scats during winter. The wolves were occasionally observed nibbling blades ($n=3$) of a grass *Sehima nervosum*.

The wolves keep visiting the kill site and sniff around it until almost everything has been consumed. In July 1992, I found that four individuals of the Nannaj Pack of 12 kept coming to the kill for four consecutive days. Sometimes the pack was spotted on kill sites where nothing (except few bones) was left unconsumed.

7.3.4 Predation Patterns

Prey fall victim to wolves due to a variety of factors such as parasites, viral infection or injury. Usually a very young crop of the prey population or old individuals are vulnerable. Some individuals become very weak during drought period thus becoming an easy target for wolves.

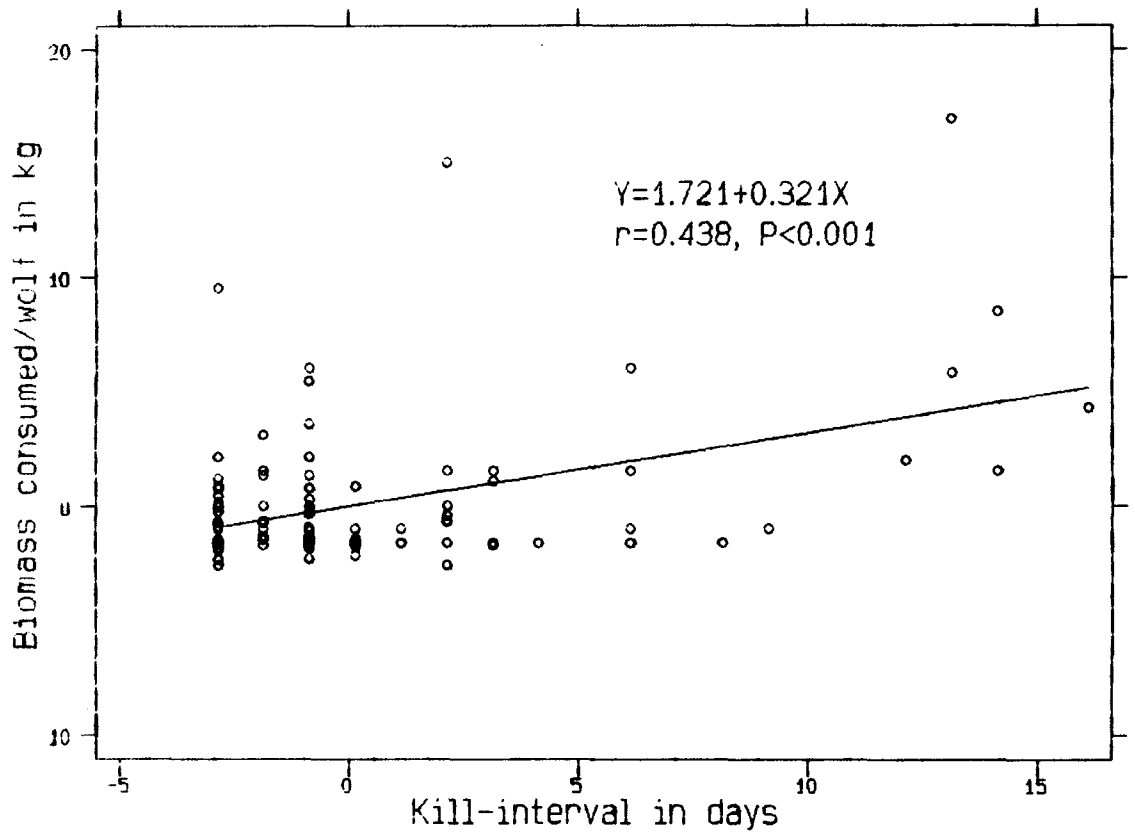


Fig. 7.5 Regression of biomass consumed by wolves on kill-interval

During this study on wolves, predation on wild and domestic ungulates was one of the major investigations. During the 1991-92 breeding period, a total of 99 kills were located in the "territory" of the Nannaj Pack. Maximum number of prey were Blackbuck (46%), followed by goat (37%) and sheep (16%) (Fig. 7.6). Therefore, livestock contributed about 53% of the total kills.

During the 1993-94 breeding period, 76 kills were recorded in total. Percent composition of each prey species is given in Fig. 7.7. The interesting findings that emerged from the analysis of the predation patterns of wolves are:

1. Predation pressure upon Blackbuck by wolves was significantly (U=461, P=0.01, Mann-Whitney U test) higher than on livestock during the non-breeding period of wolves (Fig. 7.8 and Fig. 7.9).

2. Wolves were found to have a strong selection for male Blackbuck (U=42, P=0.01, Mann-Whitney U test) despite the higher availability of female individuals in the population (refer Tables 4.1 and 4.2).

3. During the non-breeding period, wolves were found to depend largely on the primary prey species (i.e., Blackbuck), but during the breeding period, livestock is the major prey (Fig. 7.8 and Fig. 7.9).

4. There was no seasonal difference of predation on Blackbuck during 1992-93 (Kruskal-Wallis Test, H=4.38, P=0.11) but differed significantly during 1993-94 (Kruskal-Wallis Test, H=5.688, P=0.5). This was mainly due to the fact that the pack size changed during these years.

Fig. 7.6 Composition of the wolf prey species during 1991-92

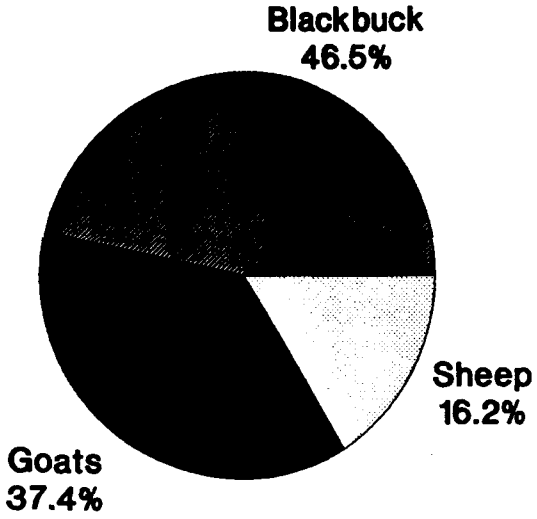


Fig. 7.7 Composition of the wolf prey species during 1993-94

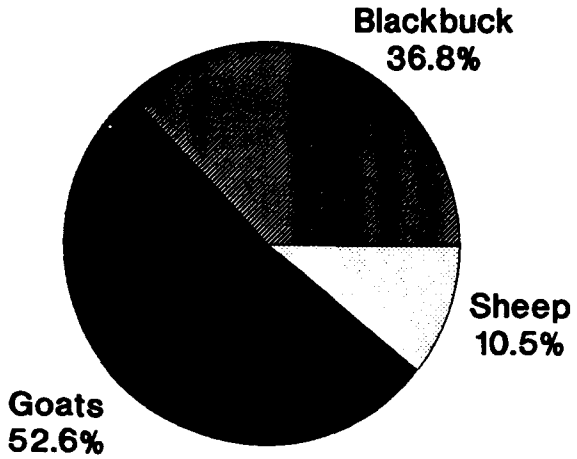


Fig. 7.8 Wolf predation on Blackbuck and livestock (Goats & Sheep) during 1991-92

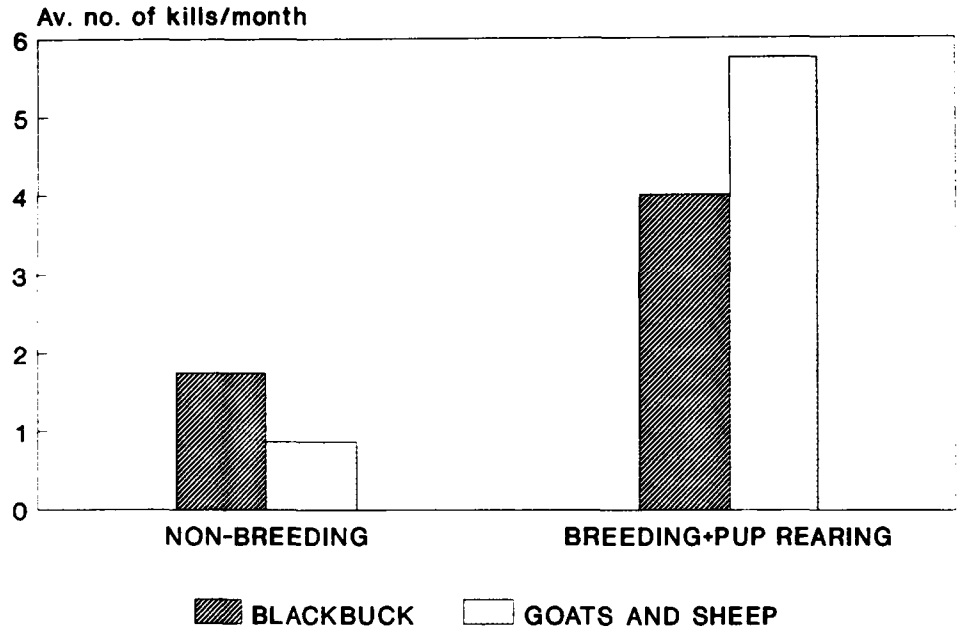
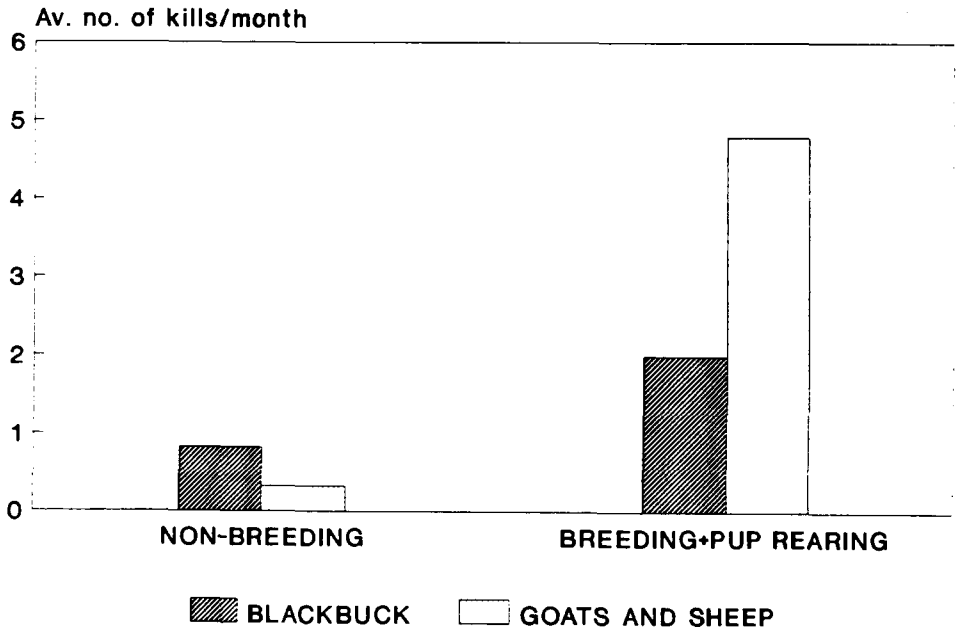


Fig. 7.9. Wolf predation on Blackbuck & livestock (Goats & Sheep) during 1993-94



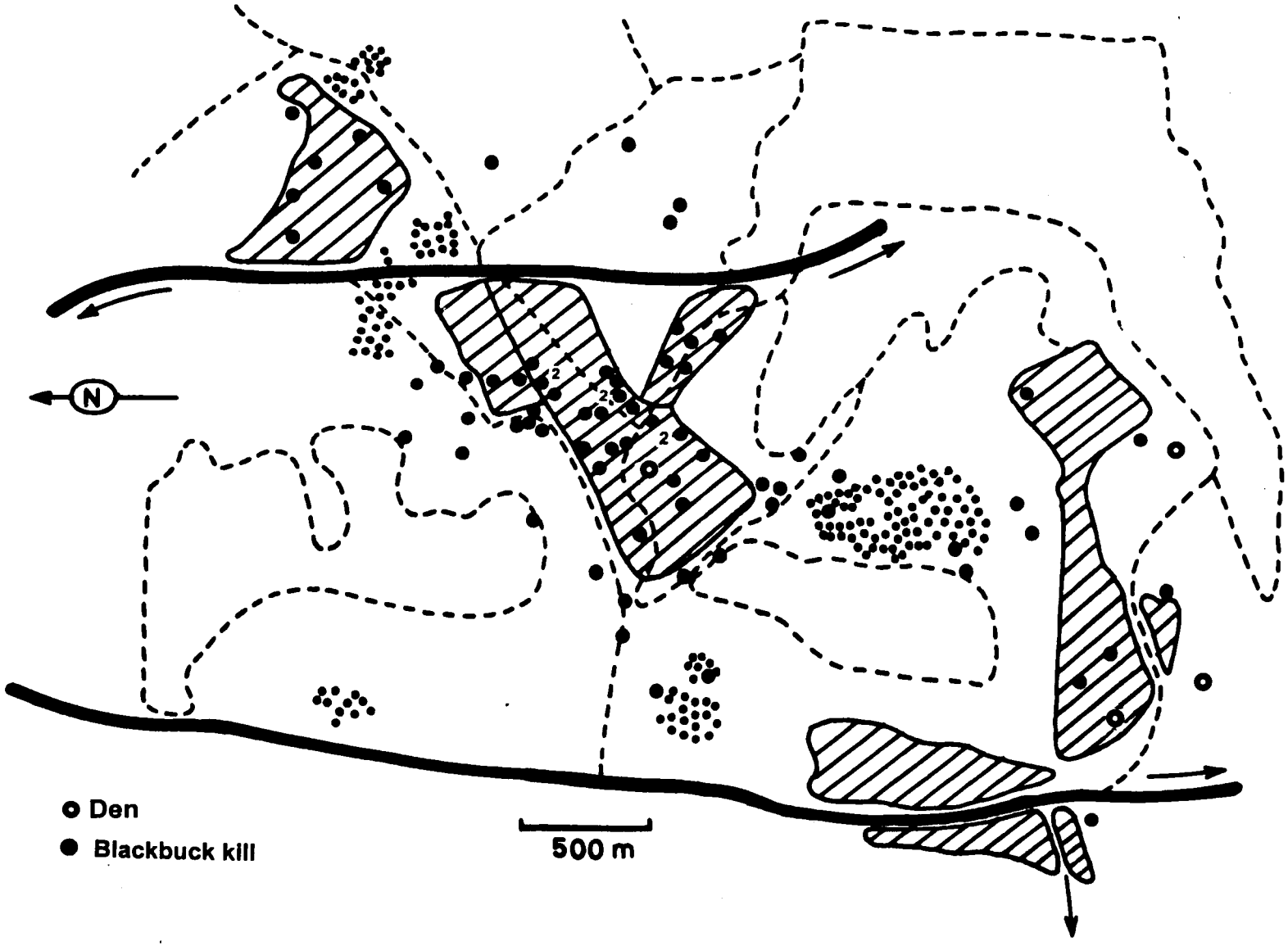


Fig. 7.10 Spatial distribution of Blackbuck killed by wolves in the Great Indian Bustard Sanctuary at Nannaj between July 1991 and August 1994. Numbers represent the animals located at the same site

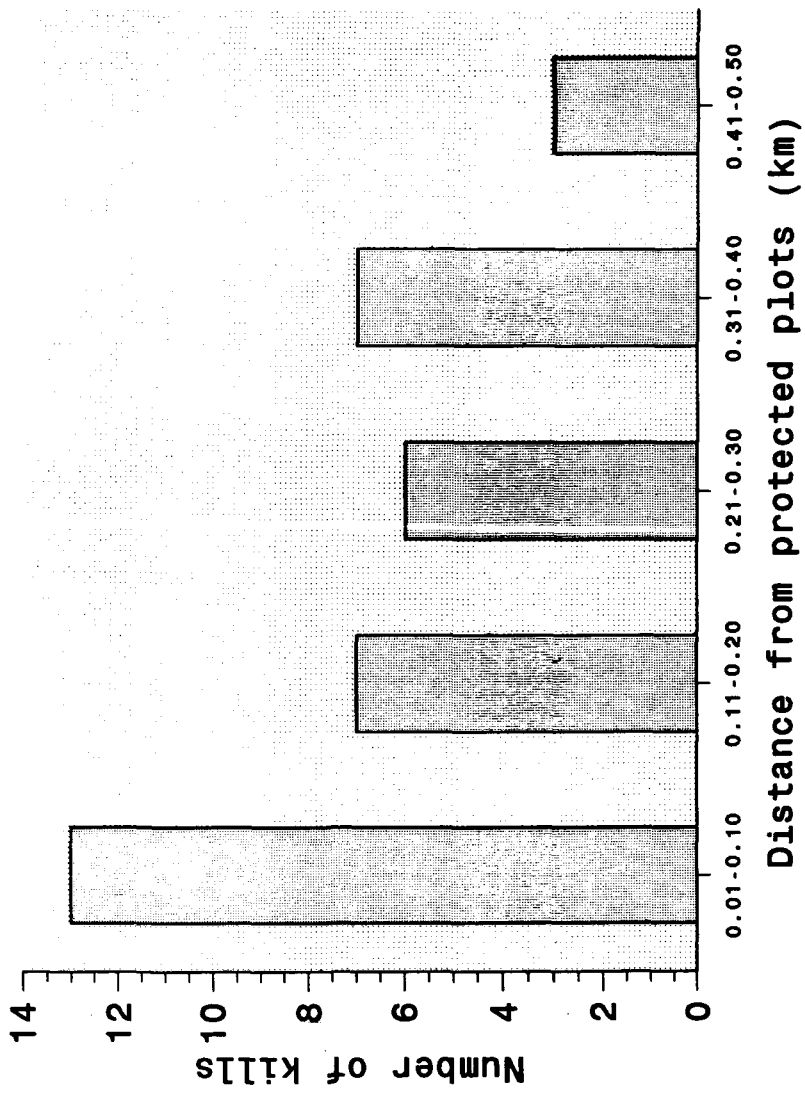


Fig. 7.11 Frequency of occurrence of Blackbuck kills at different distance intervals (1991-1994)

7.3.5 Spatial Distribution of Kills

During daylight hours, the wolves were seen most of the times in the protected plots of the Sanctuary. Therefore, more than half of the kills (52%) were located in grassland and plantation plots of the Sanctuary (Fig. 7.10). The remaining (48%) kills were found in grazing land close to the protected plots. The maximum distance of Blackbuck kill from the protected plots was 0.5 km. Of the 36 (48%) wolf kills of Blackbuck located in the grazing land, 36% kills were located next to the Sanctuary at a distance of 0.01-0.10 km. 19% kills were at a distance of 0.11-0.20 km, 17% at 0.21-0.30 km, 191% at 0.31-0.40 km and just 8% of kills at 0.41-0.50 km (Fig. 7.11).

7.3.6 Kill Utilization

The maximum amount of the kill remains recovered from any of the kills was about 16.5 kg of an adult Blackbuck doe. The number of wolves recorded feeding on the kill were two. The minimum amount of unutilized biomass of a kill was 0.5 kg for an yearling male, 3 kg for an adult fully grown male, 1.7 kg for a fully grown adult female and 1 kg for an yearling female. The probable number of wolves suspected to have fed on the above kills were three, eight, nine and six respectively.

For the remaining kills, the biomass left unconsumed other than the rumen contents included horns, skull and the backbone vertebrae. On three occasions, limbs were also left unconsumed. The latter were recovered in 1993 when there were only two wolves left in the territory.

There was a clear pattern of feeding on kills by wolves than stray dogs. The dogs left most of the kills unutilized whereas the wolves feed very neatly on the kill leaving behind only the thick bones. Sex-age composition of Blackbuck killed by wolves in the G.I.B. Sanctuary is given in Table 7.5.

For some of the wolf-killed (?) Blackbuck (n=5) it was not possible to distinguish them from those killed by dogs. The dogs used to stay away by 150-200 metres from the kill. The wolves sometimes were seen threatening stray dogs and chasing them off from the kills which sometimes even lead to fights.

7.3.7 Vegetation around the kills

Wolf is one of the carnivores in which the senses of olfaction, vision and hearing are very strong. Sight is used as a tool in hunting in the open areas (grassland and scrubland) whereas olfaction is used in hunting in the "closed" habitat types (plantations). They can hear the howling of other wolves at a distance over 6.5 km (Mech 1970).

The maximum number of Blacbuck kills (29%) were located within 1-4 m distance from vegetative cover. The minimum number of the kills (5%) were at a distance of about one meter from vegetation (Table 7.1). All these Blackbuck were probably ambushed by the wolves. Of the remaining kills, 11% were within 5-8 m, 8% within 9-12 m, 15% within 13-15 m, and 13% were within 16-20 m distance. It was not possible to make out the exact location of about 19% wolf-killed Blackbuck. The fawns were hunted in open grasslands.

Table 7.5 Sex-age composition of Blackbuck killed by wolves in the Great Indian Bustard Sanctuary, Nannaj (July 1991-August 1994)

Year	Adult		Sub-adult			Fawn	Wolves
	M	F	M	F	U		
1991*	10	-	1	2	2	6	7
1992	17	7	5	3	2	3	12
1993	8	4	-	-	1	4	2
1994**	7	2	2	1	1	1	8

* includes kills from July to December
** includes kills from January to August

M = Male
F = Female
U = Unsexed

Table 7.1 Distance of Blackbuck and livestock kills from the nearest vegetation cover

Prey type	Distance from nearest vegetation cover					
	<1 m	1-4 m	5-8 m	9-12 m	13-16 m	17-20 m
Blackbuck	4	22	8	6	11	10
Livestock	4	50	16	9	1	_

7.3.8 Seasonal variation in kill rate

There was no significant difference in frequency of occurrence of kills (Kruskal-Wallis one-way analysis of variance test, H=0.090, P=0.956) during different seasons of the year.

7.3.9 Distribution of kills in different habitats

There was a significant (G=98.9, P=0.05) difference in distribution of kills among different habitat types (Table 7.2). The grassland and plantation habitats were preferred by wolves in relation to the availability of these areas. Wolf-killed Blackbuck were found in scrubland habitat in relation to availability. The grazing land was avoided by wolves since the number of kills found in this habitat was less than expected (Table 7.3). 37% of the kills were found in grassland, followed by scrubland (18.67%), plantation (21.33%) and grazing land (18.67%).

Table 7.2 G statistic for the log-likelihood ratio goodness of fit test for distribution of Blackbuck kills in different habitats

Habitat	Rel. area (ha)	Obs. Kills	Exp. Kills	ln (obs./exp.)	Obs.x ln (obs/exp)	G=2∑obs. × ln (obs/exp)
Grassland	0.085	28	6.38	1.48	41.44	G = 98.9
Grazing land	0.711	14	53.33	-1.34	-18.76	
Scrubland	0.133	17	9.98	0.53	9.01	
Plantation	0.070	16	5.25	1.11	17.76	
		∑ x=75			∑obs.× ln(obs/exp) = 49.45	

X^2 = 7.81 (Tabulated), d.f. =3, P=0.05

Table 7.3 Simultaneous Bonferroni confidence intervals for occurrence of Blackbuck kills in different habitats

Habitat Category	Total Area (ha)	Rel Area	Exp Kills	Obs Kills	Exp Prop Kills	Bonferroni Conf Intervals
Grassland	134.00	0.185	6.375	28	0.085	$0.234 \leq p \leq 0.513^{***}$
Grazing land	1378.13	0.711	53.325	14	0.711	$0.074 \leq p \leq 0.299^{*}$
Scrubland	257.81	0.133	9.995	17	0.133	$0.106 \leq p \leq 0.348^{**}$
Plantation	136.00	0.071	5.250	16	0.071	$0.095 \leq p \leq 0.332^{***}$
Total	1936.94		205.00	205		

* The no. of kills found were less than expected
** The no. of kills found were in proportion to availability of the habitat
*** The no. of kills found were more than expected

The distance of wolf kills of Blackbuck from Sanctuary plots during denning period was similar to the distance of kills during non-breeding period (Two-sample Kolmogorov-Smirnov test, D=0.2463, P=0.462).

The distance of kills from the dens did not differ significantly (Mann-Whitney U test, U=366.50, P=0.30) during the denning period and the remaining period of the year.

7.3.10 CACHING OF FOOD

Food caching in carnivores involves hiding food from conspecifics. It has been reported in Leopard (Ewer 1973, Seidensticker 1976), Tiger (Johnsingh 1983), North American Wolf (Harrington 1981), captive Coyotes (Harrington 1982), Red Fox *Vulpes vulpes* (Macdonald 1976) and African Wild Dog *Lycaon pictus* (Malcolm 1980). Food caching was observed in the Nannaj Pack only twice during the study period. A single wolf who was left behind after the pack moved from the kill site, was observed in the morning (07:00 H) to hide food with the dried grass lying next to the kill. The wolf did not make any effort to dig a hole and hurriedly covered the food with grass and rushed to reach its packmates that had already moved. Upon examining the site, it was found to be a part of the hind leg of female blackbuck weighing about 750 g. The remaining kill had totally been consumed by the pack (seven members).

On another occasion, in July 1992, a juvenile wolf brought a part of some animal leg and dropped the same in a ditch having tall herbaceous growth and went away.

There was no other wolf seen around that area for two hours. Later the leg was found to be a part of the hind leg of a cattle which kept lying in the same ditch for several days without being attended by any of the pack members.

The same behaviour of caching food by wolves was also recorded by Ranjit Manakadan in 1993 (pers. comm.) in Rollapadu Wildlife Sanctuary in Andhra Pradesh. Food caching if performed at an individual level is a selfish behaviour in species such as the Wolf which is a highly social carnivore and contradicts the degree of cooperation for their sociality in terms of group hunting and cooperative rearing of pups. If food caches are not shared with other members of the pack, the act is apparently a selfish behaviour.

7.3.11 Antipredator Behaviour (Predator Avoidance)

When chased by wolves Blackbuck fawns used to course zigzag in grasslands instead of running straight. Observations on Wolves-Blackbuck interactions (diurnal hunts) are low. The sequence of hunting which resulted in killing of Blackbuck was observed only twice during the study period, but unsuccessful chases were observed several times (n=13). Following were the predator avoidance strategies of Blackbuck during these unsuccessful hunts:-

1) When a large herd of Blackbuck was approached by the wolves, the adult males used to come to the fore-front of the herd facing the approaching wolves. Such reaction of the prey makes the wolves scared to enter the herd. When two wolves tried to make their way into the herd, one was aggressively hit by a buck with horns.

2) The defensive strategy most frequently used by Blackbuck in avoiding their encounter with the wolves was to flee rapidly.

3) Ground stumping, flashing tail and galloping as high as possible in air when the flight distance between the predator and prey was short. Blowing air briskly from the nostrils and producing a grunting sound to alarm the remaining individuals of the group.

4) As reported earlier, the fawns used to course zig-zag and many times were successful in getting away from wolves.

7.3.12 Biomass Availability and Harvest (Impact of Wolf Predation on Blackbuck Population)

It is extremely difficult to exactly assess the impact of Wolf predation on Blackbuck population since the predator-prey ratio is highly flexible, spatially as well as temporally. There is immigration as well as emigration of animals during drought periods which are frequent in Solapur region.

During the study period, maximum number of Blackbuck were counted in 1991 followed by 1994 (see Table 4.1). The total biomass of Blackbuck available to wolves between 1991 to 1994 was 56,058.5 kg. Of the available biomass of Blackbuck, I calculated that the wolves could harvest only 3% (1991), 7% (1992), 3% (1993) and 2% (1994) (Table 7.4).

Table 7.4 Blackbuck biomass in the Great Indian Bustard Sanctuary and its harvest by the wolves

Year	Available biomass of Blackbuck in kg*	Biomass removed by wolves in kg	Av. weight of Blackbuck kill ± S.D.	# of kills
1991	15,195.5	461.00 (3.03)	21.95 ± 14.50	21
1992	13,190.5	942.50 (7.15)	25.47 ± 11.80	37
1993	13,199.5	420.00 (3.18)	24.71 ± 13.02	17
1994	14,473	347.50 (2.4)	24.82 ± 12.79	14
Total	56,058.5	2171.00		89

* Calculated from the data given in Table .

Values in parentheses represent percent biomass of Blackbuck harvested by wolves

If 10% of a kill is not utilized on an average so about 5,606 kg biomass can be subtracted from the total biomass removed by wolves between 1991 and 1994. Of the total biomass of Blackbuck available to wolves (56,058.5 kg), they removed only 3.87% and 4.3% if biomass of the kill remains (unutilized parts of prey) is subtracted from the total. Thus Blackbuck which fall prey to the wolves annually is quite low. Therefore, the harvest by wolves will not affect the population of Blackbuck.

The proximate cause of mortality of Blackbuck was found to be predation by wolves. By removing the oldest, sick, injured and diseased individuals from the prey populations, the wolves help maintain the prey population.

7.4 Discussion

The higher number of males among wolf-killed Blackbuck support the study on wolves in North America by Stenlund (1955), Pimlott *et al.* (1969), Mech *et al.* and Frenzel (1971).

Kruuk (1976) has reported food caching in adult as well as sub-adult Striped hyaenas *Hyaena vulgaris*. They push down the object to be stored into the vegetation with the snout making no attempt to cover it up. The similar behaviour of caching food was observed in Brown hyaena *Hyaena brunnea* whereas in Spotted hyaena *Crocuta crocuta* the occurrence was rare and different as they simply dropped food in water (Kruuk 1976). This behaviour is more primitive than the

food-caching by canidae. The latter dig a pit or a hole and cover the food with earth or vegetation (Kruuk 1964; Mech 1970).

"I have observed wolves caching food under many circumstances: around large kills, burying whole hares, regurgigating into holes and caching it, covering halves of calves, etc." (L. D. Mech 1997, pers. comm.).

Rare occurrence of food caching could be due to maximum consumption of the kills. Whenever a kill was left partially consumed, the pack kept returning to the same several times. One kill lying close to the road was frequented by the wolves for four days consecutively. The Timber wolves have also been observed to remain close to their kills for a period of 1-7 days, depending on how recently had eaten (Mech *et al.* 1971).

Wolves are known to risk their existence while attempting to kill large prey species (Murie 1944; Rausch 1967; Mech 1970; Peterson 1977). The large prey species include Moose *Alces alces*, White-tailed deer *Odocoeilus virginianus*, Musk-ox *Ovibos moschatus* and Bison *Bison bison*. Rausch (1967) has found many skulls of wolves collected in a control program which had sustained injuries, probably inflicted by several blows from Moose.

The wolves might have been killing Blackbuck in areas far away from the most frequently utilized core area of the Sanctuary particularly when only two of them were left in the pack. It has been reported that the larger packs had a lower kill rate than did single wolves or pairs.

The single wolves probably could kill deer just as easily as could packs (Mech *et al.* 1971).

Most of the studies having discussions regarding impact of predators on prey populations are targeted to have been speculative with a number of assumptions with reference to predator-prey management.

The difficulties in assessing the limiting effect of wolf predation on ungulates arise mainly due to the methodological problems associated with measuring the impact of functional and numerical response of predators to changing prey densities. The method is speculative and involves many assumptions in predator-prey models. Therefore, the alternative approach with minimum assumptions was employed to look for the prey killed by wolves for this study.

7.5 Limitation

The wolves were not radiocollared, it is very likely that they would have killed Blackbuck outside the Sanctuary which might have been missed during the study. So the biomass which has been computed as removed by wolves may be an under-estimate of what actually is removed by them.

CHAPTER EIGHT

PREDATION ON DOMESTIC UNGULATES

8.1 Introduction

Indian Wolf is one of the smallest wolves of the world. It is unique with regard to the environment in which it lives in comparison to most of the races of wolves in the world. Its conspecifics are attracted to garbage dumps around human settlements and are reported to be more of scavengers than carnivores in Israel (Mendelssohn 1983a, b) and to goats and sheep carcasses in Saudi Arabia (Iyed A. Nader 1992, pers. comm.). This behaviour is not recorded in the Indian Wolf.

The wolf exists discontinuously all over the GIB Sanctuary. The Sanctuary covers numerous villages, towns, crop fields, grazing lands and some pockets of forest land. Therefore, woif-human conflicts are common, chiefly because of wolf depredations on livestock namely goats and sheep.

Some studies concerning livestock depredations by predators have been done. For instance, cattle losses to Coyote *Canis latrans*, Black bear *Ursus americanus*, Wolf and Mountain lion *Felis concolor* (Dorrance 1982, Gee 1979), predation losses of domestic sheep to Coyote (Dorrance and Roy, 1976), livestock depredations by Wolves (Fritts 1982), wolf-livestock conflicts (Fritts *et al.* 1992). Similar studies in India are lacking.

Estimation of depredation by wolves is essential to implement compensation

payments, planning management and long-term conservation of the wolf. The present study on livestock depredations in this part of India is an attempt to answer these questions.

Wolf predation on livestock populations remains a highly complex and hotly debated issue in India and in several areas of its geographical range in the world because of the problem of confirming depredations, irrelevant claims by shepherds, farmers, and ranchers, differences of opinion over depredations, and exaggerations of the facts. An attempt was made to assess the magnitude of the wolf-man conflict resulting due to livestock depredations.

8.2 Methods

Data on livestock depredations were collected by doing ground surveys and also from the information given by shepherds and farmers around the Sanctuary. They were encouraged to report any incidence of wolf depredation to me for further investigation. Additionally, personal interviews were conducted while taking field observations on wolves. Sometimes, kills were located opportunistically while doing ground-surveys for wolf.

Attempts were made to minimize a single major bias of false claims which comes underway while enquiring farmers to get their reports on livestock losses to wolves. This was achieved by doing thorough investigation of the claims. A livestock depredation complaint by wolves was considered as authentic if our investigation revealed some evidence such as wounded animal, remains of the victim, blood

stains on grass in freshly reported cases, wolf tracks, chase sequences on the ground and signs of struggle. Physical examination of the kill site was done immediately after receiving a report.

The wolf is the only large predator in the study area so there was no confusion regarding possibility of depredations by any other predator than the wolf. The farmer and shepherd community supplied some facts on wolf behaviour particularly on the depredation events occurring at nights. During the study period I occasionally stayed with shepherds at nights to observe activity of wolves around villages and also to confirm some of the information supplied by them. All alleged depredation complaints were corroborated without further delay to have more information.

On receiving a complaint of depredation by wolves, information such as sex and age of the kill, whether the kill was rescued or not, 'sheep dogs' and habitat type were collected. The terrain, vegetation height at the kill site and nearest vegetation cover from the kill were also recorded.

To investigate the interactions between livestock and wolves i.e., their hunting strategy, I used to select some elevated areas in the Sanctuary to randomly scan herds of sheep and goats grazing or browsing.

Total counts of livestock were done on a weekly basis around the Sanctuary area to assess the population of goats and sheep. Some elevated spots in the Sanctuary with higher visibility were selected for counts. The counts were done between 14:00

and 16:00 hours during which maximum number of these animals are expected around the Sanctuary. Livestock refers to the goats and sheep in the entire text.

8.3 Analyses

All livestock kills were grouped into the following three breeding periods:

1. Breeding period: December 1991 - November 1992: Breeding seen
2. Breeding period: December 1992 - November 1993: No breeding seen
3. Breeding period: December 1993 - November 1994: Breeding seen

For some analyses, the breeding periods (when breeding was seen i.e., 1 and 3) were further sub-divided into two periods:

a) Denning and post denning period till the pups were dependent on parents and other members of the pack (helpers) for food (December to May).

b) Post denning period when juveniles start hunting with the parents or on their own. This was observed between June and October after which they start separating and dispersing and sometimes the pack members were seen in very loose associations.

This was done to test any difference in depredations when (i) the pups were restricted to dens or rendezvous sites, (ii) the juveniles started hunting, and (iii) when no breeding was seen.

Nonparametric statistical analysis was performed on the data. Differences in predation on goats and sheep were tested by chi- square test. Difference in depredations during the breeding period 1 and 2, and 3 and 2 were tested by using Mann-Whitney U test whereas Kruskal-Wallis one-way analysis of variance was

performed when the kills were grouped into three categories (a, b and 2). Since data collection was completed in August 1994 so difference in depredations (3 and 2) for the year 1993-94 was only for eight months.

Monthly variation in livestock abundance during 1992-94 was tested by using chi-square tests. The pack size of wolves during the study period was not constant so the livestock kills were averaged out for doing various comparisons.

8.4 Results

As reported earlier, the Nannaj Pack bred during 1991 and 1993 but not in 1992 due to severe drought. The annual precipitation was only 442 mm vis-a-vis 750 mm so the prey populations had dispersed over a very large area. The pack size of wolf varied from 2-12 individuals.

During the study period, a total of 101 individuals (77 goats and 24 sheep) were attacked by wolves. Of the 16 individuals (13 goats and three sheep) mauled by the wolves, only three goats and one sheep survived. All these individuals showed bites on their necks, muzzles and heads. Of the total kills, 16% were retrieved by the owners either by chasing the wolves or with the help of 'sheep dogs' or 'livestock guarding dogs'. Twenty goats were killed by wolves at night and the remaining during the daylight hours. The night kills are not shown in Fig. 8.1 since on an average most of them (14) were located beyond three km which could be in accord with the higher activity of the pack at night and thus ranging over a large area. Including these kills would distort the general pattern emerging from the day kills since the latter

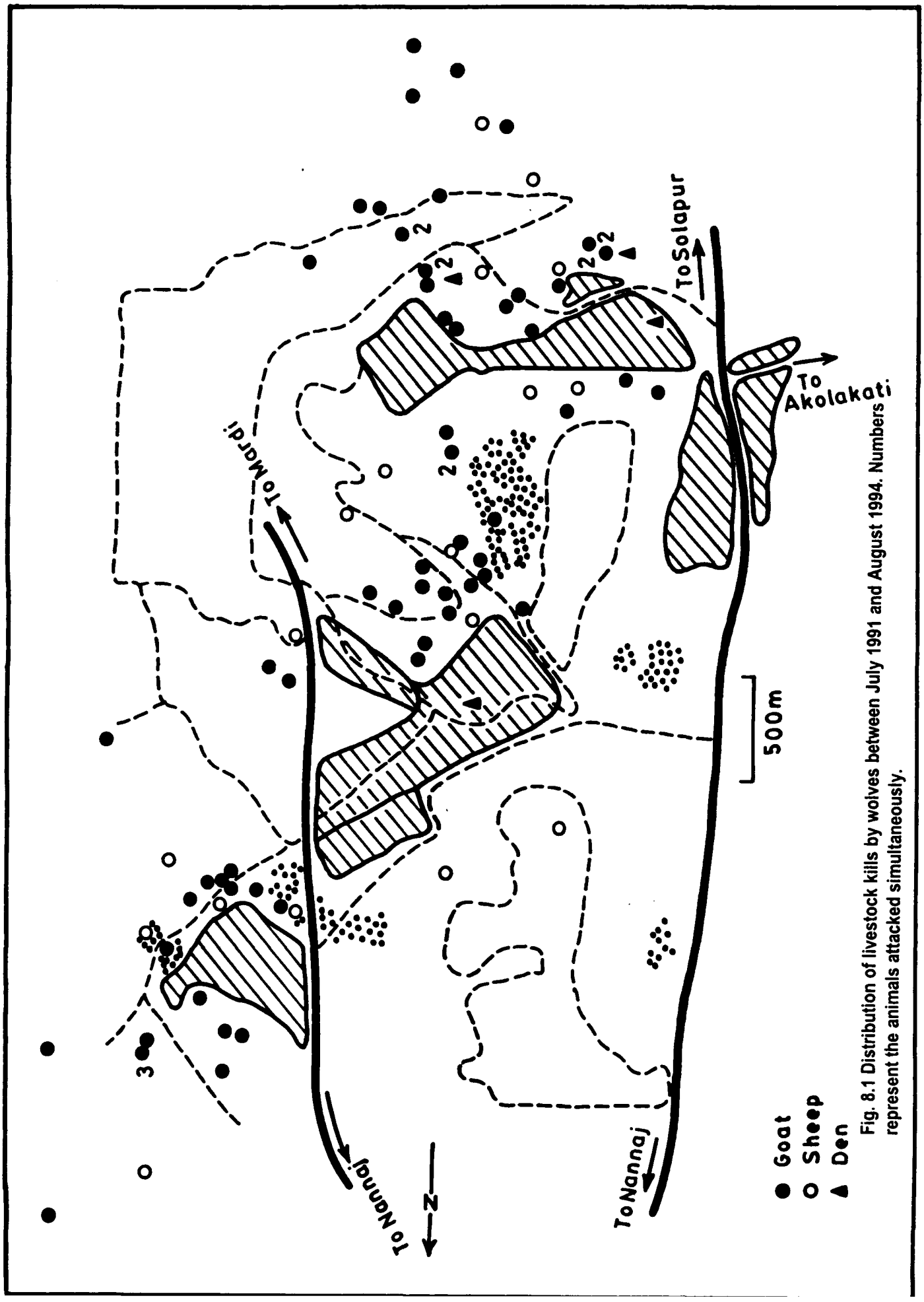


Fig. 8.1 Distribution of livestock kills by wolves between July 1991 and August 1994. Numbers represent the animals attacked simultaneously.

are closer to the protected core areas of the Sanctuary.

During 1991-92 (covering monsoon 1991 and winter of 1991-92), of the 12 kills, maximum depredations (N=11) occurred in winter followed by monsoon (N=1). This could probably be due to the absence of pups with the parental pack during monsoon of 1991 and the presence of five pups in winter of 1991-92. During 1992-93 (covering summer and monsoon 1993 and winter of 1993-94), maximum kills were found to be in monsoon (50%) and summer (43%) and the remaining in winter of 1992-93 (Table 8.1) which is probably again due to the presence of pups during monsoon and summer and low pack size during winter when the pack disassociated and dispersed. During rains, shepherds shelter under trees while their livestock graze in a wide area so wolves get an opportunity to attack their livestock herds which are temporarily unguarded. This was observed four times, the description of each event is given below:

On 4th August 1992, a wolf came out from a bush (14:50 H) where a goat went to browse and attacked the goat. Three more wolves joined and killed the goat. One small dog accompanying the shepherds kept barking and did not go near wolves. Two of us chased the wolves that started tearing apart the goat by dragging it little further. The wolves ultimately left the kill. The goat was bleeding profusely from the head. It had been raining and I was standing under an *Acacia* tree with the shepherd. The wolves attacked the 14.5 kg goat 20m from us.

On 27th August 1992, a mixed flock of 70 sheep and goats was moving away from

four shepherds while grazing (16:00 H). It had been raining for the last one and half hours. The flock had moved about 25m from the shepherds when a wolf came out from a bush and jumped on a goat fawn and carried it away into the plantation. The fawn was lagging behind about 4 to 5m from the flock. There were seven more wolves standing near the boundary wall of the plantation plot. All the wolves entered into the plantation.

Similarly on 2nd September 1992 (15:08 H), a single wolf attacked a sheep (fully grown adult female). When the 'sheep dog' started charging at the wolf and four more wolves that were standing 50m away, joined the single wolf. The wolves started attacking the flock of 25 sheep and eight goats from all sides and thus confusing the dog. The dog approached a wolf attempting to attack an individual but the other wolves were also making attacks simultaneously from other sides. A gravid sheep (about 20 kg) was killed by the pack members and the dog tried to guard the flock against the wolves till it was chased away by two wolves. The sheep was seriously mauled by the wolves and died after two hours. The struggle between wolves and dog lasted for three and half minutes.

On 3rd July 1994, it had been raining continuously since 19:00 H. On rainy nights the wolves were reported going into the villages. I stayed at Mardi village, about four km from Nannaj. I was sitting behind the thatched door of a shepherd in the village. The hut was situated opposite to the corral and I was able to see everything through the thatched door. Two wolves (probably the alpha pair) came around 22:00 H. One wolf went into the corral by pushing the thatched door sideways which was kept at

entrance to the corral. The second wolf went back. The wolf which could make his entry into the corral took a goat fawn and ran away. The shepherds were requested not to make noise. The hut and the corral of the shepherd were located on the outskirts of the village. They were later compensated for the loss of a lamb.

The next morning, it was found that wolves had killed another goat (adult female) the same night around 23:30 H on the other side of the village. The goat was rescued by the people by chasing away the wolves. The wolf entered the corral by jumping over the wall which was about one meter high.

On 7th July 1994, it had been raining since 15:00 H. There were two flocks of sheep and goats grazing in the Sanctuary area. One flock comprised of 20 sheep and the other was a mixed one having 70 individuals. Three shepherds were sheltering under a bridge when two wolves attacked their livestock. Eight wolves came out of a depression with small bushes, where they had been hiding. One of the adult wolves attacked a subadult sheep (female) weighing 8-10 kg and dragged it 100 m away from the neck but it was dropped after the shepherds chased the wolves and threw stones on them. Another reason for dropping the kill could be the weight of the sheep which the wolf was not able to drag with ease.

The sheep was not able to balance itself after it was dropped by the wolf. Inspite of four bites on her neck and one on the head, it survived. No dog had accompanied the shepherds. The sheep and goats produced a typical grunting or sneezing alarm sound when the wolves attacked.

No livestock kill was reported in summer and monsoon of 1993, a drought year. This was because the shepherds had migrated to other areas where rainfall was relatively better. Some shepherds stayed back with few herds of livestock which were spread over a wide range. The wolves likewise ranged over a larger area in search of food so there was a likelihood that some kills went undetected. Only two wolves were left in the territory of the Nannaj Pack in 1993, so food requirement was low. Depredations were again conspicuous during winter 1993-94 and summer of 1994. Of the 38 kills, the wolves made maximum (74%) in summer 1994 (Table 8.1) *followed by winter 1993-94 (N=10).*

The maximum depredations occurred during summer 1992 and 1994 and also during monsoon 1992 which was apparently due to the higher demand of growing pups for food. Moreover, wolves obviously would rely on easy prey at such times.

Occasionally, two or more goats were killed by wolves. On six occasions, we actually saw wolves hunting and killing goats and sheep.

The livestock population of five villages in the G.I.B. Sanctuary namely, Nannaj, Mardi, Akolakati, Vadala, and Narotewadi was much higher than the actual numbers grazing around the sanctuary because some of them go to other areas. Our maximum counts were 743 sheep and 410 goats in 1992, 1190 sheep and 531 goats in 1993, and 1706 sheep and 813 goats in 1994 (Table 8.2).

Table 8.1 Domestic ungulates killed by wolves during different seasons from 1991-1994 in the Great Indian Bustard Sanctuary, Nannaj

Season		Livestock depredations		Total
		Goats	Sheep	
Monsoon 1991	(mid June-mid Oct)	0	1	1
Winter 1991-92	(mid Oct-Jan)	10	1	11
Summer 1992	(Feb-mid June)	13	6	19
Monsoon 1992	(mid June-mid Oct)	14	8	22
Winter 1992-93	(mid Oct-Jan)	2	1	3
Summer 1993	(Feb-mid June)	0	0	0
Monsoon 1993	(mid June-mid Oct)	0	0	0
Winter 1993-94	(mid Oct-Jan)	9	1	10
Summer 1994	(Feb-mid June)	24	4	28
	Total	72	22	94

Table 8.2 Average number of goats and sheep month^{-1} around Nannaj (1992-1994)

Month	1992		1993		1994	
	Goats	Sheep	Goats	Sheep	Goats	Sheep
January	212.4 (24.3)	525 (56.5)	100.5 (16.2)	190.2 (7.7)	510 (27.8)	1102.4 (73.3)
February	110 (14.2)	420.8 (33.8)	90.4 (5.7)	197.1 (13.6)	490.5 (16.4)	992.6 (39.7)
March	104.2 (30.9)	405.6 (21.3)	104.6 (19.7)	210 (32)	461 (49)	890 (106.2)
April	108 (6.7)	247.5 (17.8)	102 (10.2)	233 (31)	366.2 (35.4)	825.5 (28.5)
May	198 (27.5)	256 (33.1)	269.8 (27.3)	456.2 (46.2)	375.2 (16.87)	674 (18.2)
June	215.2 (60.6)	654.4 (67.8)	251 (11)	720.4 (36.9)	408.8 (34.9)	914 (66.1)
July	301.3 (65.2)	524.1 (46.2)	320 (33.2)	712.5 (40.2)	622 (23.5)	1510 (46.1)
August	398 (15.7)	618 (18.9)	350.5 (41.9)	795 (45)	715.5 (79.1)	1496 (172.7)
September	292.2 (15.3)	430.5 (32.3)	400 (10)	930.6 (56.6)	-No data-	
October	157.5 (12.9)	210 (15.5)	362.3 (10.8)	810 (11.2)	-No data-	
November	140 (14.7)	192.2 (18.1)	460.5 (48.6)	967 (16.5)	-No data-	
December	106 (14)	185.4 (11.7)	517 (18.6)	1136.6 (46)	-No data-	

Values in parentheses represent Standard Deviation

The maximum number of the kills (52%) made during day time were found upto a distance of 0.2 km from the protected pasture and woodlot plots of the Sanctuary. About 4% were found at distances equal to or greater than 1 km from the Sanctuary. The remaining (44%) kills were found between 0.2-1.2 km interval from the Sanctuary plots (Fig. 8.2).

The linear distance of diurnal wolf kills of livestock from the protected plots of the Sanctuary (Fig. 8.1) varied from 0.01 to 1.25 km ($\bar{X}$=0.3 km, N=81). On the other hand the distance of the kills from plots made during nights varied from 3.0 to 3.5 km ($\bar{X}$=3.2 km, N=20).

63% of the kills were found at a distance of 1-4 m from a bush or some other vegetation cover. Only 1% kills were at 13-15 m distance from the nearest vegetation cover (Fig. 8.3) which implies that most of the victims must have been ambushed by wolves.

Depredations claimed by the farmers and shepherds should be interpreted cautiously because people sometimes give false information. During this study period, seven false reports were given by the local people. Most of the farmers and shepherds envisaged that the wolves enter their livestock corrals on the outskirts of the villages during the monsoon season particularly when it is raining. The corrals generally have one metre high walls which wolves can easily jump over. They could be opportunistic at the slightest laxity in alertness on the part of the watchman guarding such livestock confinements. This was confirmed four times by staying with the shepherds. Over a

Fig. 8.2. Occurrence of livestock kills at different distance intervals

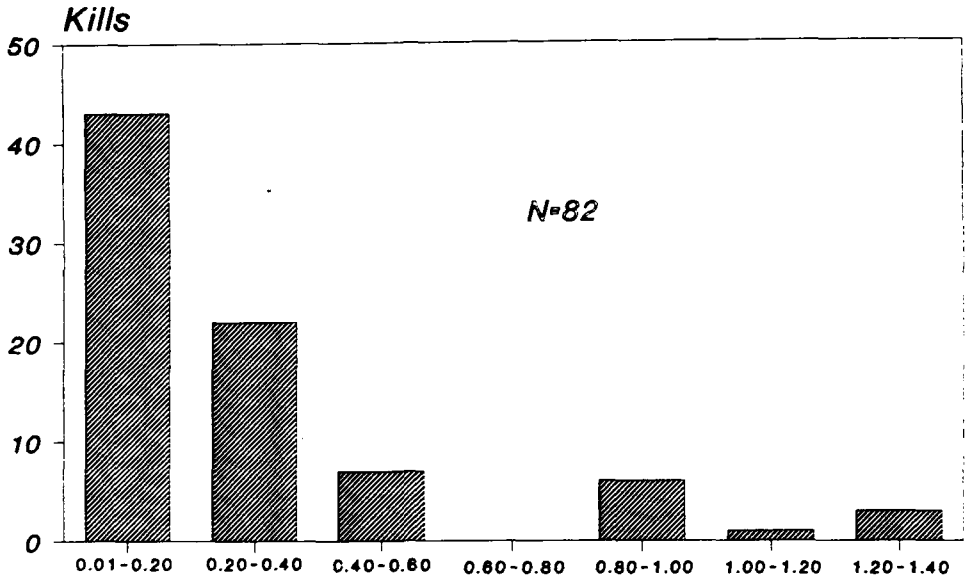
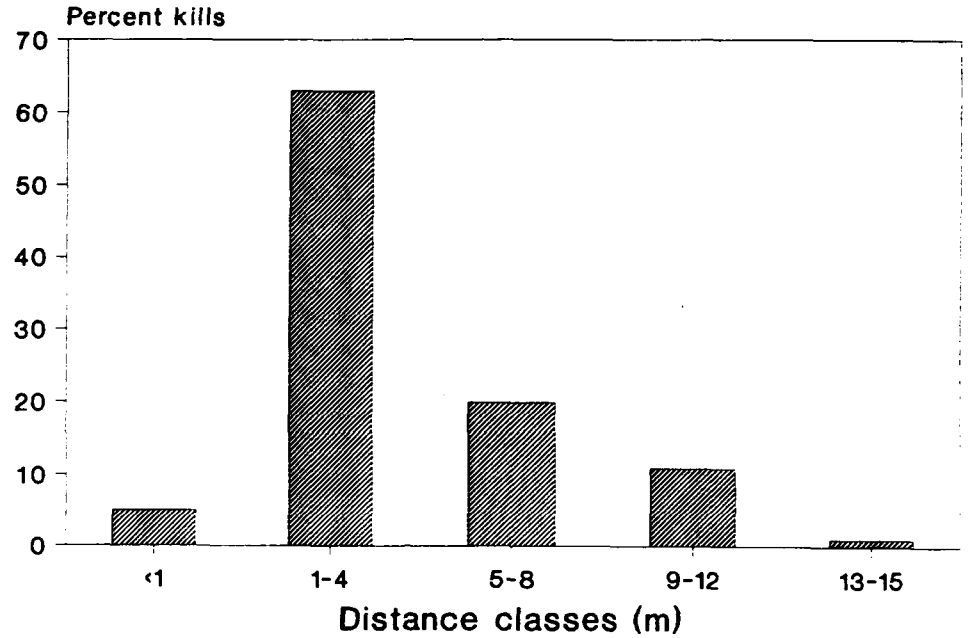


Fig.8.3 Relation between occurence of livestock kills and distance from cover



period of time, wolves must have learned this habit of attacking animals at corrals during a rainy night because on a rainy night all people shelter in their hutments and dogs also take shelter.

The wolves killed significantly more number of goats and sheep during breeding years 1991-92 ($U = 2631$, $P<0.001$, Mann-Whitney U Test) and 1993-94 ($U = 1280$, $P<0.01$, Mann-Whitney U Test) than during the non-breeding year (i.e., 1992-93).

When the three periods namely a, b, and 2 were considered for breeding periods of wolves during 1991-92 and 1993-94 (see data analysis): depredations were significantly higher during the denning period of 1991-92 (Kruskal-Wallis Test, test statistic $H=48$, $P<0.001$) as well as of 1993-94 (Kruskal-Wallis Test, test statistic $H=14.3$, $P<0.01$) when pups were dependent on parents and/or helpers for food followed by the period when juveniles also start hunting. Depredation was low during the non-breeding years.

There was differential predation on goats and sheep. Goats tended to be significantly ($X^2=14.25$, d.f.=1, $P<0.001$) more susceptible to wolf depredation than sheep during the study period (i.e., 1991-1994) inspite of higher availability of the latter (Table 8.2). The ratio of goat to sheep was 1:2.76. Similarly there was a significant difference between the number of goats and sheep killed in 1992 ($X^2=8$, d.f.=1, $P<0.01$) and 1994 ($X^2=9.13$, d.f.=1, $P<0.005$). This may be because of either one or a combination of the following factors: (1) Goats were ambushed by wolves since they browse shrubs and short bushes, and (2) They were more dispersed as compared to the

compact herds of sheep.

There was a monthly variation in the abundance of goats and sheep in our study area. The number of sheep always outnumbered goats from 1992 through 1994. There was a significant difference for 1992 (X^2=8, df=1, P<0.01), 1993 (X^2=5, df=1, P<0.05) and 1994 (X^2=11, df=1, P<0.01) in abundance of sheep and goats.

8.5 Discussion

Any damage by wildlife in a developing country like India is a major concern for politicians, agriculturists and wildlife conservationists. We have scanty information on wildlife damage problems. This lack of information can lead to controversial decisions as how to manage a specific wildlife damage problem (Berryman 1984). Because of all these intricacies, a comprehensive national policy to evolve adequate compensation payments to solve wildlife-human conflicts is hampered. The wolf population has witnessed some resurgence in Nannaj area of Solapur after establishment of the Great Indian Bustard Sanctuary in 1980. At least the wolves have become visible due to less harassment by people after protection of the area.

The wolf is basically programmed by birth to hunt wild prey. They become a problem and result in confrontations when they harm man directly or indirectly by depredating livestock species such as goats, sheep, cattle, pigs and sometimes poultry.

The wolves go for multiple attacks to divert the attention of 'sheep dogs' (i.e., to confuse them). By the time the 'sheep dogs' come to defend the attacked individual,

other pack members make another attack and the dogs get confused. By employing this strategy, wolves are successful in killing livestock, even when they are 'defended' by dogs.

The position of wolf in Maharashtra and overall in India is not secure as it lives in the interfaces between agricultural and grazing land. They are poisoned and killed indiscriminately particularly over wolf-man conflict originating due to depredations. Recently, during March-October 1996, there were reports of 63 children being killed and attacked by wolves in three districts of Uttar Pradesh namely Pratapgarh, Jaunpur and Sultanpur. I did a survey of these crisis-ridden areas during August-September 1996 to investigate the alleged reports of killings and wolves were found to have done these killings. In this part of India, wolves have turned child lifters because their habitat has been destroyed and occupied under intensive agriculture and they have no prey base to survive on. This has resulted in extreme public animosity towards wolves throughout the country. Due to such aberrant behaviour of the wolf, coupled with livestock depredations, it is difficult to have public support towards its conservation in India.

Unlike wolves in Israel and Saudi Arabia, the Indian Wolf does not frequent garbage dumps around human settlements and its behaviour is more like a carnivore than a scavenger. The main reason is that goat/sheep carcasses are not left for long period. In India, first of all, very few goats/sheep are allowed to die natural death - even sick animals are sold! Even if few of them die, they are quickly skinned and the meat is eaten.

There is no provision of giving livestock compensation to farmers for wolf depredations by the Indian government. Most of the livestock owners - shepherds, *Dhangars*, farmers are very poor (average annual income, less than U.S. $ 300) and loss of even a single goat or sheep is substantial to them. The farmer and grazier community suffer on two accounts: their common grazing land is taken under different soil conservation and afforestation schemes and secondly they lose their livestock to wolves. Under these circumstances, one of the most important questions to be considered for wolf conservation is the payment of adequate compensation by the government (Sawarkar 1986). Currently in India, compensation payments are made only for the animals killed by Tiger and Lion.

The utilization of prey by predators in the nature reserves has been found to depend on many circumstances and it changes in space and time (Filonov 1980). At Nannaj, the Wolf litters during December-January and the pups leave the den in February or early March. Most of the livestock killing occurs from December to May. During this time the shepherds try to kill wolves or pups in the dens. There is a tribe called, *'Dhangars'* who keep goats and sheep and their livelihood depends entirely on selling these domestic ungulates and their products. They live over the entire geographical range of the Sanctuary. Once an active den is located, they fumigate and block the den to kill wolf pups or sometimes even the adult wolves.

An adult goat which weighs 15-16 kg costs about U.S. $ 48 whereas a subadult (8-10 kg) around $ 28 and sheep costs almost the same. Based on my investigations of

wolf-livestock conflicts during 1991-1994, the total monetary losses of livestock due to wolves in the study area were of about U.S. $ 3,246 and 2,319 $ if the individuals retrieved by graziers are not considered. This loss occurred within an area of 20-25 km^2. A state program in the United States which compensates farmers for livestock destroyed by wolves has been paying an average of U.S. $ 32,170 per year (Paul 1995) for the single state of Minnesota during the past few years. The program provides compensation as high as $400 per animal killed or injured by wolves (Fritts *et al.* 1992). Similarly depredation by wolves on sheep in Italy has been reported to be 20-50% of the alleged wolf damage reported by farmers (Zimen and Boitani 1979). There are very few published accounts of livestock losses to predators in India. It is not possible to compare the magnitude of the problem in other wolf areas due to lack of information on this aspect. To have further knowledge of the wolf behaviour, depredations and their comparative account, a long term research on wolves in many areas is necessary.

CHAPTER NINE

BREEDING BIOLOGY

9.1 Introduction

The wolf is a highly social animal and these social bonds are firmly revealed by the fact that the members of a pack remain together. The entire pack cares cooperatively for the breeding female and the pups.

One of the reasons why such strong ties exist between different members of a pack is the long association of pups and parents and/or foster parents when they raise them. This period of socialization is very important in developing such contacts which result in strong bonds among litter mates and other members of the pack. The younger animals also stay in close contact to each other during denning and post-denning periods.

Most of ecological investigations on wolf breeding have been done in captivity (Cheney 1982; Fentress and Ryon 1982; Harrington *et al.* 1982; Lentfer and Sanders 1973, Lyons *et al.* 1982; Paquet *et al.* 1982; Zimen 1982). Due to their extensive movements and elusiveness it is very difficult to observe mating behaviour of wolves in the wild particularly when radio-transmitters are not fitted to the animals. As a result of which little has been recorded on the behaviour of the Indian Wolf. This chapter describes limited information regarding pre-denning, denning and post-denning behaviour of the Indian Wolf.

Ecological information was gathered on its breeding habits and then interpreted and correlated with the conditions and circumstances prevailing in the study area.

Wolves attain sexual maturity at the age of 22 months or when they are almost two years old (Raush 1967a, Rabb *et al.* 1967, Mech 1970, Murie 1944, Pullianinen 1965). Sometimes they show breeding activity after one year of age (Mech 1970). However, Lentfer and Sanders (1973) reported that males may not show breeding activity even at the age of 22-months. Gestation period of wolves is reported to be 62±3 days (Brown 1936; Woolpy 1968).

Usually the top-ranking male and female i.e., alpha male and alpha female or in other words the dominant wolves are the only members of the pack which breed. Rarely two females breed in a pack.

Multiple litters are known to occur infrequently (Murie 1944). Paquet *et al.* (1982) recorded concurrent pregnancies in wolves at the Washington Park Zoo, Portland, Oregon. In the absence of adults, sometimes ten months old wolves are known to mate and produce pups in captivity (Medjo and Mech 1976, Zimen 1976), but in the presence of adults, they do not breed until almost two years old.

I found that the wolf at Nannaj mates during October-November and gives birth during December-January. Published account of literature on wolves reveals that the Indian Wolf is the only race that breeds during winter compared to the temperate wolves that breed during summer. There is no information available on the mating behaviour of the Indian Wolf either in captivity or in wild populations.

9.2 Methods

The study area was searched for dens during December-January each year and those areas where wolves were sighted consecutively for 2-3 days were scanned in particular. Once an active den was located, observations on wolves were taken at dens and rendezvous sites. A hide was constructed approximately 300 m from the den to observe activities of the adults as well as the pups. A thatched hut constructed in one of the Sanctuary plots was also used to observe wolves.

Once the wolves were used to my presence, the hide was gradually moved closer. They were habituated by following them for a period of about eight months. The same route was used to reach upto the hide and return from it. Wolf tracks along paths and animal trails, and repeated defecation along particular paths provided some information about their movement during their denning season.

On some occasions, observations were curtailed to minimize disturbance. However, it was possible to record few observations on wolf behaviour at dens and rendezvous sites. As the number of observations were limited and descriptive, it was not possible to do statistical analyses.

The dens were examined after they were vacated and abandoned by the wolves. All important measurements of the dens viz., diameter, width, height and length were recorded during this time. A stick was used for this purpose. The approximate length of each den was found out by putting the head in (whenever possible) through the main entrance and inspecting it from within with the help of a focusing

search light. I crawled into one of the dens (den #3) upto one meter which was partially dug by the local people (probably shepherds since the general public is usually afraid of wolves).

Interior of the dens, activity sites and trails leading to the dens have been described in results. Direct observations of wolves were made mostly at their rendezvous or post-denning activity sites because usually it was not possible to approach wolves and maintain contact with them at sites other than the rendezvous and denning sites.

The activities of the pack were recorded at the dens and rendezvous sites to describe the relationship of the pack members with these sites throughout the year i.e., pre-breeding, breeding and nursing periods.

Mortality was assessed from the number of pups seen at denning sites in the beginning and when they left the dens.

The alpha male was aggressive whenever I encountered him at close quarters (20-35m). The alpha male always reacted in defense on such occasions and charged at me whereas the alpha female always moved away silently along with other pack members or alone as the case may be. Besides the coat colour and markings, such cues on the behaviour were also used to identify them from the rest of the packmates.

9.3 Results

During 1991-1992, some of the pack members were observed to restrict their movement around a particular area for 2-3 weeks before the pups were born. Similarly one of the two wolves (prabably the female) was seen around the den for one month during 1993-1994.

The dens were burrows in the ground or ridges along percolation tanks. Wolves either constructed/excavated the den(s) or they merely enlarged the holes of other animals such as Common Indian Fox *Vulpes bengalensis* and Monitor Lizard *Varanus bengalensis*. Wolf tracks leading to den entrances were seen around the denning sites from all sides.

9.3.1 Mating activity

On October 11, 1992 two wolves were seen together for 20 minutes. One wolf was observed sniffing genitals of the other and both individuals were rubbing their heads with each others body. This activity lasted for six and half minutes intermittently. However, no mounting was observed.

9.3.2 Selection of the denning sites (Location)

All the dens were located on slightly elevated areas near some water source. Selection of little raised area for the den could possibly be (i) to have a view of the surrounding areas from the den and (ii) for better drainage or both these factors.

Three dens were located under rock boulders in Solapur district on the hills. The description of dens seen during the Wolf survey in Solapur is summerized in Table 9.1. The soil under these rocks was soft and porous which could easily be dug by wolves. All dens were more or less located towards the centre of the territory. Generally, the dens were located near a water source. The distance of the den from the water source varied from 0.18 km to 2.48 km.

9.3.3 Pre-denning activity

Three pack members were seen first time at den #1 on 13 December 1991. The den was in a Reinforced Concrete Cement (R.C.C.) pipe (Appendix-A). The alpha female littered in this den during December 1991 as wolf tracks leading into or radiating out of the den entrance were seen around this area during the entire month of December.

The pack did not breed in my study area in 1992 probably because of the drought. In 1993, the alpha male and the alpha female were sighted in Shambar plot on December 24 (06:15 H). One of the individuals disappeared after 2 minutes at the same spot. Later upon investigating the area, a den was found (den #2) in the plot. Shambar plot is the largest and best protected grassland plot of the Sanctuary. The alpha female did not litter in this den and it was discarded by wolves because of the disturbance by labourers working at a distance of 100m from the denning site.

During late December 1993, the wolves were again seen for 12 days consecutively in Shambar plot. On January 4, 1994, the alpha male came running towards me

Table 9.1 Description of dens seen during wolf survey in Solapur with important habitat parameters

Range	Dimensions H x V	Habitat charateristics
Malshiras	105 x 40	Located along slope in open area under an acacia tree (1)
Malshiras	108 x 29	Located under a rock boulder, plantation, in use as tracks seen (1)
Sangola	90 x 35 82 x 28	Located under a rock boulder, under a tree, in use as bones seen inside
Sangola	100 x 29 78 x 21	Located in an open area, grassland (2)
North Solapur	55 x 55	Located in an open area, grazing land (1)

HxV= Horizontal diameter x Vertical diameter (cm)

Figures within parantheses is number of den openings

aggressively when I was about 25m from a den which I discovered later. The alpha female turned away quietly whereas the male continued barking at me for five minutes and stopped when I was about 50m from the den. The alpha female littered in this den.

9.3.4 Denning habits

The wolves start preparing dens weeks before parturition. A gravid female begins remaining near the den about three weeks before giving birth (Mech 1970). The bitch confines herself to the den about a day before the birth of the young (Schonberner 1965). The fox burrows are sometimes excavated and enlarged by wolves. The Indian Wolf has been observed to behave similarly in Velavadar National Park (Jhala 1991). When wolves enlarged the fox burrows, there were usually two to three main entrances to the den and there were more aeration chambers into the den. Seven dens of the fox which I examined in the study area had 4-8 burrows. The burrows used to enter into or exit from the den were much larger than the aeration burrows. The dens are sometimes renewed for reuse year after year (pers. obs.) .

During 1994, while rearing pups, I found that the alpha pair used four dens. The wolves were observed making two dens simultaneously and later during the same time they were found using four dens simultaneously shifting pups from one to the other owing to disturbance. The den constructed first was not at all used by the wolves because of labourers working near it. The distance between first and second den was 1.5 km, between second and third 540 metres, third and fourth 300 metres.

The second and fifth were located within the core areas of the Sanctuary whereas the remaining three were outside the protected plots in the grazing land with heavy livestock grazing pressure and several stone quarries.

The Reinforced Concrete Cement (R.C.C.) pipes were used by **Nannaj Pack** for denning both during 1991-92 and 1993-94 (Fig. 9.1). The Gangewadi Pack also used R.C.C. pipe outside the protected plots in 1992-93, four pups were seen in this area. The R.C.C. pipes are laid in percolation tanks to regulate the flow of water from these water reservoirs during rainy season. Since the area is drought prone, water is stored in these tanks during monsoon and used for irrigation and for cattle in the winter till it lasts.

The relationships between the dens and first and second rendezvous sites, dens and water sources are listed in Table 6.11 (see Habitat use and preference).

9.3.5 Structure of the dens

Four dens were constructed and used by the pack during 1993-94 when the young were born whereas only one den was used during 1991-92. Another den used only for few days was the same den where the pups were raised in 1991-92 whereas the remaining were burrows in the ground.

The description of the different dens with their internal burrows system is given below and their location, habitat types and slopes have also been summarized in Table 9.2. All dens found during the study period from beginning to end are

Table 9.2 Location of different dens with elevation, slope and major habitat features at the study site

Den #	Year	Location	Elevation	Exposure and Habitat
Den-1*	1991-92	Adjacent to Mardi-2 Plot (125 m)	324 m	South-facing slope, crop fields 80 m from the den
Den-2	1993-94	Shambar Plot	402 m	Southwest-facing slope, grassland, plantation strip 91 m from the den
Den-3	1993-94	Near Mardi-2 Plot at the ridge of the percolation tank, under *Prosopis* tree (78 m)	387 m	Ridge facing East-west, grazing land
Den-4*	1993-94	Adjacent to Mardi-2 Plot (125 m)	324 m	South-facing slope, crop fields 80 m from the den
Den-5	1993-94	Mardi-2 Plot	389 m	East-facing slope, grassland

* Both these dens represent the same den which was used by wolves during 1991-92 as well as 1993-94. The had been in use for the past 9-10 years (second-hand information)

numbered from Sr. no. 1 to 5 (Table 9.2). The interior channel system of each den is illustrated in Appendices A, B, C, and D. The sketches show the number of entrances to the particular den and the underground burrow system.

DEN #1: The den used during 1991-92 was with one burrow measuring 15m in length and 0.51m in diameter. It was an artificial den, made of R.C.C. pipe lying in the percolation tank (Fig. 9.1). The pipe was used to regulate the flow of water from the percolation tank during the rainy season. The pipe was straight having uniform diameter terminating into a bulge of 1.5 x 1.5m. Five pups were born and reared in den # 1 during 1991-92.

DEN #2: This den was located in Shambar plot and also had only one entrance. The den was 2.6m long and was located on an elevated land (Fig. 9.2). The width of the entrance was 0.54m and the vertical height was 0.69m. The channel of the den after a distance of 1.25m turned slightly to the right and terminated into the main chamber called 'nursery chamber'. The latter was little larger than the diameter of the main burrow. There was another burrow about 0.38m wide on the left of the main burrow at 1.25m from the den entrance.

DEN #3: The den was originally a burrow of the Common Indian Fox which was excavated and enlarged by the wolves. There were two large entrances and one medium size entrance and four smaller aeration holes. So the den had three entrances and passageways. The alpha female gave birth to six pups (?) in this den, before shifting them to other dens.

Fig 9.1 Den #1 in the Reinforced concrete cement pipe used during 1991-1992

Fig 9.2 Den #2 located in the grassland plot during 1993-1994

One large and one medium-size entrances joined the tunnel of the main entrance at a distance of 0.85 m and 1.75 m respectively. The main burrow after going into the ground at a distance of 1.56m turned right and terminated in an enlarged chamber which measured approximately 1 x 1m. The newborn pups were probably kept in this slightly enlarged chamber. The total length of the den was 2.85m.

It was located under a *Prosopis juliflora* tree of roughly 4.5m height (Fig. 9.3). The roots that passed through the burrow were cut open by the wolves.

DEN #4: This was the same den used by wolves during 1991-92 (Fig. 9.1 and Appendix-A).

DEN #5: The den was excavated by wolves after giving birth to young in den #2. There were two openings in this den, one much larger than the other (Appendix D). The smaller opening of the den was located on the Trench-Cum-Mound (T.C.M.) wall (Fig. 9.4) of the Mardi-1 plot at Akolakati. The den was situated 80m from a non-mettaled road and was exposed to disturbance.

The larger opening of the den was 0.27m wide and the vertical height was 0.95m. The burrow of the larger opening after a distance of about 40 cm turned slightly upward and then tangentially toward right side (facing south) into the TCM wall and ending in an enlarged bulging. At about 0.23m from the angle of turning towards right, the main burrow of the den led into another channel (0.3m wide) on the left hand side (please see Appendix-D). The smaller opening was located on the T.C.M. wall and was found to end in an enlarged chamber of the main tunnel. It probably

Fig 9.3 Den # 3 located on the ridge of a percolated tank during 1993 -1994

Fig. 9.4 Den # 5 located adjacent to the trench cum mound wall of a grassland plot during 1993-1994

served as an aeration device rather than as an exit or entrance into the den. The total length of the den was 2.75m. It was located 175m from the water source.

Den #2 and 5 were located in the hard, rocky ground and possibly because of this these dens were comparatively shorter in length than the other.

All the dens were located in elevated and well drained areas. All but one (den #3) were close to water source (<0.5 km). Den # 1 was about 0.15 km from the water source. The distance of dens from water source ranged from 0.15 to 0.55 km except for den # 3 which was 0.92 km from water.

The maximum distance between two dens constructed simultaneously during 1993-94 was 2.33 km. The dens were closer to the first and second rendezvous sites.

9.3.6 Litter size

Average litter size in the North American wolves has been recorded as 6.5 (Mech 1970) and 6.0 to 14.5 (Carbyn *et al.* 1993). Promberger *et al.*(1996) have reported the litter size in the **Carpathian Wolf** *Canis lupus* as eight. The average litter size of the Indian Wolf was found to be five with a range of four to six. The average litter size available for a single pack during three and half years study was found to be 5.5. These numbers represent the pups seen after they had left their natal dens or during the time when they used to make short visits around the den. The mortality within the dens is unknown.

9.3.7 Activity at whelping dens

During late winter and early summer, the pack focussed its activities around homesites (dens and rendezvous sites). So the homesites become the focal point of activities of the pack during these periods.

In 1991, the pack was observed at den during mid-December and in 1993 during late December. The pups were observed at den as late as February 10, 1992 and February 24, 1994. Pups are known to begin eating meat and leave the den for short spans when they are about three weeks old (Mech 1970). Till this time they suckle mothers' milk.

I found that the pups emerged first time from the den on 10 January 1992 and on 25 January, 1994. Observations on emergence of pups and wolf den usage pattern suggested that parturition occurred between 20 and 31 December in 1991 and late December in 1993 or early January in 1994.

Pups stay within their natal dens approximately for two months (Mech 1970). They remain in dens for this period if not disturbed by humans. During both the breeding years, I observed that the dens were abandoned by pups before they spent two months within them due to human disturbance.

After 25 January 1994, the pups were observed regularly coming out of the den and going to a distance of about 10 m from the den entrance, when there was no disturbance. On 25 January 1994, the alpha female came out of the den at 18:28 H

followed by five pups. All were smelling ground while moving on the ridge of the percolation tank where the natal den was situated. The alpha female went down and up the ridge towards the entrance of the den twice followed by pups. The litter mates played amongst themselves for 10 minutes along the slope of the percolation tank. During play activity, they ran and bit each other.

On 26 January 1994, the pups came out of the whelping den at 18:30 H, when the alpha male went and stood near the den. The young ones were observed playing for five minutes and vanished into the den in no time upon hearing an alarm call of the Common Indian Fox.

The young pups were extremely sensitive during their short visits outside the den. They used to run towards den after hearing any kind of sound. For instance, sound of vehicles on the road (about 300m away), calls by Great horned owl *Bubo bubo* or Peafowl *Pavo cristatus*, galloping sound of Blackbuck and whistling by shepherds.

During 1991-92, all pack members (seven) were found together most frequently during nursing and post-nursing periods. This was due to participation in hunting by different pack members. The main activities of the pups during their short trips outside the whelping dens after 3-4 weeks of their age till they left them were suckling and playing among themselves. The playing activities initiate the concept of socialization and social order during this early stage of development in the pups.

On two occasions, the pups attempted to nurse twice but the female rebuffed them by jumping sideways. The pups used to come out of the den during the evening hours which could probably be because of the low temperature in the morning since they were sighted only twice outside the den during morning hours.

On 2 February 1994, when the pups had already been shifted to den #3 (Please refer to den shifting), the alpha male came to the den at 18:00 H and four pups came out immediately from the den. They started licking muzzle of the male and all went under the body of the male and attempted to suckle when the male jumped to the side and ran away. One pup also followed the alpha male for short distance but soon joined his companions, going into the den. A few days later similar interaction occurred between pups and the alpha male.

The alpha members were vigilant while coming to the den. Whenever the parents came to the den, they did not enter it to bring the pups out but instead they used to stand near the den for some time, waiting for the pups to come out.

During the breeding year 1991-92, the alpha male and the alpha female were found guarding the den more often than the helpers or auxiliary members of the pack (X^2= 35.44, P<0.01, d.f.= 1).

The alpha male was seen more often guarding dens than the alpha female (X^2=26.9, P=<0.01, d.f.=1) during 1993-94.

On seven occasions in two months (January-February), I saw wolves carrying a goat or sheep inside the den.

With an increase in age of the pups they spent more time outside the den. The maximum duration for which pups were observed around dens before they had abandoned them was 22 minutes. The average duration of observation of the pups was 10.8 minutes (range=3-22, N=12).

The wolves did not pay any attention to Blackbuck passing by or grazing around the den. Twice a solitary Blackbuck was also seen grazing near den which was not paid any attention or disturbed by the wolves. The wolves did not kill any Blackbuck or livestock adjacent to the den except for one road killed female Blackbuck that was brought near den #3 (Kumar 1996).

9.3.8 Relationships between adults and den sites

The adults as well as the auxiliary members were not seen using the dens after they were vacated by the pack during February in both the breeding years. In other words, the pack was not using the dens like other canid species such as Common Indian Fox, Jackals *Canis aureus*, which use the dens for resting also during pre-breeding and pos-tbreeding periods (pers. obs.).

On 12 April 1994, two pups were seen coming out of the den #5 at 13:15 H. They were found using den #5 four times at different occasions in May 1994. This could be due to high temperature (41° to 45°C) during these months which forced them to

go into the dens for resting. After coming out of the den, the pups went straight to the waterhole located in the same plot, 0.92 km from it. In North America, captive adult wolves have been observed digging dens in summer and using them to get away from heat but no wild pups are seen using dens after originally abandoning them (L. D. Mech 1997, pers. comm.).

The wolves had been using Den #1 in Nannaj for the last 15 years intermittently. Similarly in North-central Minnesota, Fuller (1989) has reported a female of a radiomonitored pack using the same den consecutively for six years. Radiocarbon dating of bones found at a den on Ellesmere Island in the Canadian Arctic Archipelago suggested its use by wolves over a period of 700 years or more (Mech and Packard 1990).

The alpha male and the alpha female were found near the whelping den more frequently than other members of the pack. In other words, helpers spent less time than the alpha members near dens during the nursing period.

9.3.9 Communication between adults and the pups

Among the parents, on most of the occasions the alpha male (n=44, Total number of observations = 64) used to come to the den in the evening (usually after sunset) and rarely in the morning. Observing this activity was possible only during 1993-94 since only two wolves (alpha male and alpha female) were left in the territory. The male or female used to stand near the den for few seconds for the pups to come out of the den.

I suspect adult wolves making some low pitch sound near the den which pups could be able to perceive and join the parents. The other possibility could be the odour of the adults to which the pups were attracted. The method of vocal communication could not be identified since the observations were taken from a long distance. Moreover, the frequency of the vocal communication may be extremely low.

After coming out of the den, the pups used to lick or mouth the muzzles (as they usually do when parents return or bring food to a rendezvous site) of the individual visiting the den or go for suckling if it was the mother. The pups were found to be very sensitive to any sound or disturbance near the den. Hearing even a low pitch sound or any sign of danger or threat, they used to scurry down into the den.

9.3.10 Protection and guarding of the whelping dens

The adult wolves either preferred lying on the T.C.M. of Akolakati plot 25-150m from the den entrance or on the ridge of the whelping den #3. In the morning hours, one of the two adult wolves was usually not found around the den whereas they were seen sitting or lying around the den in evening hours (usually between 17:30 and 18:30 H) during 1993-94. On the other hand, they were observed sitting around the whelping den both in the morning and evening hours during 1991-92. The difference could probably be because of the presence of 'helpers' in 1991 and their absence in the pack in 1993. The term 'helper' is often used as a synonym for a non-breeding group member; but information on their helpful behaviour is inadequate. Alloparents have been known to increase the survivorship of Silver-backed jackal *Canis adustus* and probably Golden jackals *Canis aurius* (Moehlman 1979).

In carnivore societies, the guarding and defence of young ones and provisioning for them other than one's own is common. The parents were always alert around the den. Whenever they were sleeping or lying (or curled up in the morning) around the den, every few seconds ($\bar{X}$=42 sec, N=685) they looked around particularly towards the whelping den.

'Pie' or village dogs were seen close to the active dens four times and they were successfully chased by the alpha pair. On one occasion, on 4 February 1994 (07:45-0748 H and 08:00-08:03 H), the alpha pair chased two dogs standing at about 150m from den #4. This was the most aggressive encounter among all such observations. The wolves chased the dogs approximately for a distance of about 1 km. One of the dogs chased by the alpha male was bleeding after the encounter. The skin was peeled off from one of the hind legs of the dog.

On 5th February 1994, the alpha pair was observed chasing a big 'pie' dog near den #4 (07:35-07:36). The dog was overpowered by the wolves and bitten as he was heard whimpering distressfully for a long time. The wolves returned near den after chasing away the dog.

The crows hovering above the den were chased rightaway by the alpha pair (mostly by the male). Similarly the kites such as *Milvus migrans* and eagles *Circaetus gallicus* were also chased away by them from the dens or even killed (Kumar 1996). These birds of prey come to the den apparently to have an access to the readily available food with the wolves.

9.3.11 Development of pups

Pups are born in a helpless condition like domestic dog *Canis familiaris*. The pups are born blind and deaf and weaning occurs at about fifth week (L. D. Mech 1996, pers. comm). The alpha female was suspected to litter in the last week of December or the first week of January during 1993-94 and in the third week of December during 1991. The pups abandoned the whelping dens between 23 and 24 February in 1994 and between 12 to 15 February in 1992. The pups had very dark fur during January-February compared to adults. The coat colour became lighter by the time they abandoned the den.

The alpha female was observed regurgigating at the den on 20 January 1994 (14:20 H) when the pups must be 3-4 weeks old because they start consuming meat after they become three weeks old and also leave the den for short periods.

During 1993-94, two of the pups were found using den #5 five times after they had moved to rendezvous sites. There was differential growth in pups because two pups were much smaller than the remaining three. The pups grew at a faster rate after they started consuming meat.

During April-May the pups were observed calling at the rendezvous sites to which the adults responded by howling. They were also heard calling when separated from each other.

The pelage of the pups was observed to become darker again during July-August. By September-October, the pups or more precisely the juveniles almost attained the size of an adult. After this, the pack slowly dispersed.

9.3.12 Den shifting

The wolves do not leave and shift their dens if they are not disturbed at these sites. They were found to be quite tolerant or used to disturbance until an attempt was made to disturb the den. For instance, the labourers started working at quarries 75-100 meters from the den and they did not leave the den till they were disturbed by them at the den by throwing stones into it. The pack was extremely sensitive to any physical disturbance at the den. If not disturbed, the wolves usually use the same den each year.

Human disturbance is the major factor contributing to den shifting in the wolves and other canids. During the breeding year 1991-92, they used a single den throughout the development period of the pups. This den although located in the grazing land near crop fields (Fig. 6.3), there was no disturbance since it was not known to the people of the area particularly the livestock graziers. As soon as it was discovered by shepherds it was blocked by them by big stones.

During the second year of breeding, the alpha pair (the only two wolves left in the territory) excavated three dens more or less simultaneously and had to shift from one den to another frequently due to disturbances.

On January 30, 1994 (17:00 H), the alpha male was found sitting about 300m from den #2 for 50 minutes. At 17:50 H he left the area and returned at 18:15 H standing on the ridge where den was located whereas the alpha female was standing down the ridge and milking the pups in standing posture for three minutes. The female left and went to south of the den followed by all the six pups running behind the female in a line.

After going for about 200m distance, the pups suckled again for one minute. The male was moved last in the line about 50m apart from the last pup. After moving further for another 100m the female stopped and carried one of the pups in her mouth. The female was very alert looking around after moving ahead every few meters. She dropped and picked up the pup from the ground three times. The pup was probably the weakest among six. The pup was carried for a distance of about 0.5 km till it was dropped at den #4. The pups were heard whining very clearly during this event of den shifting.

I could not observe the shifting of pups to den #5, but it was abandoned due to the disturbance by farmers working in the crop fields adjacent to this den.

9.3.13 Disturbance at dens and rendezvous sites

Quarrying, livestock grazing, pariah dogs, movement of the people, vehicles coming to collect stones from the quarries, mining and blasting around the Sanctuary were the major disturbances which led to shifting and even abandoning of the dens by wolves.

During December 1993, the alpha pair constructed a burrow for den in the Shambar plot (den #2) but this den was not used by the wolves due to the disturbance by labourers who started working at 100m distance from the burrow.

The wolves constructed another den (den #3) located on the ridge of a percolation tank (see description of the dens). The alpha female littered in this den and

quarrying started around the den area about 75 m away but the wolves did tolerate the disturbance till the den was located by the workers at the quarry. The pups were shifted to den #4 (R.C.C. pipe) where the alpha female had littered during 1991-92. During this period, when the pups were in den #4, the alpha pair constructed another den (den #5) in a protected grassland plot of the Sanctuary. This den was close to a 'kachcha road' and the pups had abandoned the den and moved to the first rendezvous site by the time the graziers and the shepherds located the den.

On 7 March 1994 (07:41-07:45) two pups were seen being chased by the pie dogs for four minutes . They were coming from the rendezvous site from where they had been driven away by the dogs.

The den #1 was found blocked with stones in 1992 when the pups were inside the den. Since wolves were observed around the den during denning period so the stones were removed immediately by me. The wolves did not shift the den even after it was blocked.

9.3.14 Aggressive behaviour around dens and rendezvous sites

When approached from close quarters, the adult wolves used to bark and run back and forth with the tail inserted in the hind limbs. Alpha male was the only individual in the pack that used to growl and continue giving low pitch barks for a longtime (maximum of eight minutes). The alpha female was always found running away from the spot. This behaviour was recorded when I went near a den or a rendezvous site without noticing the presence of wolves.

In 1992, during April-May, the alpha individuals, charged me by barking in an aggressive manner upon approaching closely when the pack was with pups (N=2). There were seven wolves in the pack accompanied by five pups. On both the occasions, the yearlings did not bark, moved away from the alpha individuals, whereas both alpha male and alpha female continued barking for about six minutes as long as I stayed 40-50 meters from the pack. After first encounter, which was from a very close proximity, the pack eventually was not sighted for a week in the area used intensively by it during that time.

On January 06, 1994 (18:35 H) when an active den was approached without knowing that the den was in use by the wolves, the alpha male came running aggressively towards me and threatened me in defense by barking. I stayed at the spot without making any movement when he stopped 15 meters away and continued barking for eight minutes, after that I moved backwards slowly. The alpha female was not visible in the area due to insufficient light. The second incident occurred in March 1994. The pack was sitting at the rendezvous site with the pups when I approached the site without realizing the presence of wolves. The alpha male came running aggressively towards me and stopped at a distance of about 20 metres and continued growling and barking for eight minutes (Fig. 9.5). The rendezvous site-I (Fig. 6.3) was located in the protected plot of the Sanctuary. The alpha female left the spot immediately, following the pups which made the move first. The male left slowly following the same route adopted by the other members. The male was smelling the route now and then and also kept peeping behind.

Fig. 9.5 Alpha male charging near a rendezvous site.

Similarly the same pack spotted me while sitting in the hide on April 12, 1994 in one of the protected plots of the Sanctuary. The alpha male started barking immediately and the other members i.e., the pups and the alpha female (as there were no helpers or subordinate members in the pack) made a move no sooner than did the alpha male bark. The male continued barking for three minutes at the waterhole when it moved away into a plantation. This waterhole is next to a non-metalled road but since the wolves are usually quite used to disturbance, they were found to use the water source regularly despite the continuous disturbance throughout the day.

Another interesting observation of the alpha male was noticed around the den on 16 January 1994 when the pups had not emerged from the den. One labourer, working at the stone quarry, 75 m from the den #3 was passing by close to the den (less than 10 meters from it) was chased by the alpha male. The wolf attempted to bite the labourer (a defensive attack) but the bite was restricted only to his clothes. This attack by the wolf was from the back which was not noticed by the labourer. From that day, the denning site was brought to the notice of the people and the latter (den #3) was shifted to den # 4 (R.C.C. pipe).

On 24 February 1994, a Forest Guard was also charged by the alpha male near rendezvous site-1 while he was on inspection of the Sanctuary. The Forest Guard was threatened by the wolf by barking and approaching him in a stalking posture. Similarly the field assistant working with me and the Range Forest Officer were also threatened (again barking aggressively) by the alpha male on 5th May 1994 when they were moving around the resting site of wolves.

During summer (April to mid-June), the alpha male used to bark at waterhole whenever the pack with pups was spotted going into the water to relieve themselves from the heat by wetting their bodies (N=14). The air temperature varied from 41° to 43°C during this period. The alpha male was observed giving high-pitched barks in short spurts several times whenever I encountered him with pups or juveniles.

In North America, Murie (1944) has reported alpha males to be aggressive around dens in defending pups against bears. A captive male wolf has been reported to defend pups against humans (Mech 1970). Mech (pers. comm., 1997) has also observed an alpha female leading the defense of pups against a Musk-ox *Ovibus moschatus* and an alpha male leading defense against a human. However, some of my observations on the alpha male defending pups against a human extend these records.

9.3.15 Rendezvous or resting sites

After leaving the natal den, the pups move to a secluded, unsheltered area called rendezvous site. A rendezvous site is a meeting place of different members of the pack which is meant basically for pup rearing. Rendezvous sites have also been referred as "loafing spots" or resting sites (Young 1944). The pups remain at these sites till second or third week of March when they begin moving with the pack. Till this time the adults i.e., parents and/or alloparents hunt and bring food for the growing pups.

During 1992, the wolves used two rendezvous sites, both located in the grazing land outside the protected plots of the Sanctuary (Fig. 6.3). The first rendezvous site was located in an open and relatively flat area compared to the second and third rendezvous site. A babool tree *Acacia nilotica* was present at this site and the distance from the water source was less than a kilometer. The pups restricted their activities to this site till mid March when they shifted to the second rendezvous site 0.38 km away. In the hot weather, the babool tree provided excellent shade to the pups.

The second rendezvous site was located on a well elevated area along a mild slope. The pups remained at this site for a week and moved to a third site in the grassland plot (Shambar Plot). Before they started moving with the parents, they were observed for few days irregularly at this new rendezvous site. Rendezvous site-2 was located under a white acacia *Acacia leucophloea* tree. The shrub layer dominated by *Cassia auriculata* was thick.

In 1994, the pups moved between four rendezvous sites. The first rendezvous site was located in a grassland plot near den #5. In 1994, one of the rendezvous sites (rendezvous site-2) selected by the pack was located at the same place as selected during 1992 (rendezvous site-1). The similar behaviour of using the same rendezvous site for two years, if left undisturbed as happens regarding use of dens, has also been recorded while studying timber wolves in Algonquin Park (Joslin 1967).

All these rendezvous sites were lined with droppings, "dug out" beds, and trails within 10m radius. They had a characteristic odour like wolf droppings. Detailed characteristics of the rendezvous sites and their distribution is given and discussed separately in a separate chapter on habitat use and preference. The different variables on which Principal Component Analysis was performed have been discussed under habitat use and preference.

9.3.16 Activity at rendezvous sites

The area at rendezvous sites is dug out for lying down and for hiding. Once in February 1992, I found an adult regurgigating food at the rendezvous site-1 at 10:15 H. All the five pups started licking its snout when it regurgigated food. The adult wolf remained at the site for nearly 15 minutes and then left.

Similarly on 10 March 1994, the alpha female chased a fawn of the Blackbuck for about four minutes around rendezvous site-4 and during the chase it abandoned chasing the fawn and started for a Blacknaped Hare that was flushed from a bush. The alpha female could hunt down the hare in approximately two minutes time. The food was brought straight to the rendezvous site-4 and eaten by the four pups present there.

The pups remained around these resting sites for several days upto mid-March when their movement activity increased. They started going to waterholes three to four times a day with parents whereas during February they were observed going with the parents only once between 06:00 H and 07:15 H. The activities of different

packmates during their movement to the waterhole is discussed under 'Use of waterholes' (see Habitat use and preference).

By mid-March, the pups were not restricted to resting sites all the time. They were often seen wandering in the parental territory sometimes in smaller sub-groups. On three occasions, the adult wolves were seen coming to the resting site and taking the pups to the kill site. The alpha female was never observed suckling pups at the resting sites.

Another activity of the wolves at the resting site was howling. The wolves used to perform chorus howling during the evening hours usually after 18:30 H and occasionally in the morning hours. The whole pack would gather at a resting site and howl (N=46) whereas on other occasions in 1992, howling was only heard (N=34) around 'homesites'

In 1994, the wolves were observed howling on 3 May (18:52 H) at resting site-2 for two minutes and then all the individuals started licking one another and left the site all together. They were heard howling several times when the pups were around homesites in 1994.

On 2nd March 1994, the pups were heard "whining" at rendezvous site-1 thrice in the morning to which the adults responded each time by howling. The pups joined the adults during the last "whining" call. The pups were seen rushing towards adult members right in front of me when they started fondling the pups. One of the

reasons of "whimpering" by the pups could be their separation from the litter mates or parents for a long duration.

Another major activity of the pups at rendezvous sites was playing. This activity is an important aspect of the life of a wolf. They learn dominant or submissive behaviour during this period. The play sometimes becomes aggressive and they start fighting and biting at each other.

On 12 May 1994, I observed pups playing for 30 minutes at the rendezvous site-4. The play consists of fast chases and grabbing each other. The two pups were also heard growling at each other during this play fight. During both the years, the pups were observed playing 22 times among themselves as well as with the parents at the resting sites. The other common place for performing plays were water holes. If pups spotted some prominent object, they used to play by picking it up, running and then leaving it to the ground. A schematic representation of the life-history of Indian Wolf is given in Fig. 9.6.

9.4 Discussion

The Indian Wolf at Nannaj mates during October-November and young ones are born during December-January. R. Manakadan (pers. comm., 1996) and Jhala (1991) have also recorded denning in the Indian wolf during December-January at Rollapadu Wildlife Sanctuary (Andhra Pradesh) and Velavadar National Park (Gujarat) respectively. The denning activity at the mating season of temperate wolves, on the other hand, is usually in February-March and litters are produced

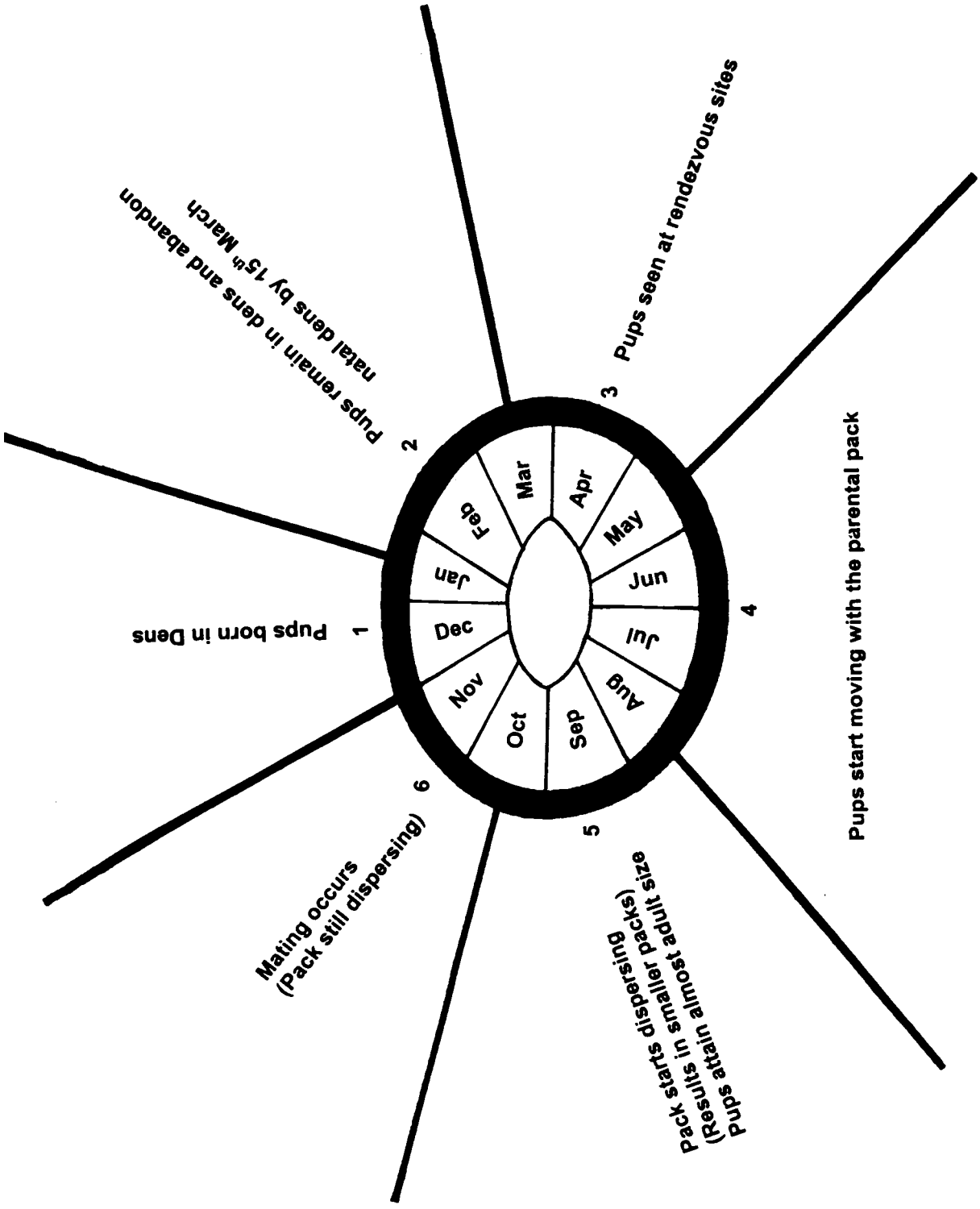


Fig. 9.6 Schematic representation of the life-history of the Indian Grey Wolf in the Great Indian Bustard Sanctuary, Nannaj

during April-May (Mech 1966a; Soper 1942), but there is variation in breeding season and denning at different latitudes both in Canada and the United States of America. Carbyn *et al.* (1993), Mech (1966 , 1970) described the breeding season of North American wolves as late winter (February), mostly during April-May. Similarly Van Ballenberghe and Mech (1975) also recorded mating activities in the Timber Wolf in Minnesota during February. The mating activity of wolves is reported during February and March in northern Alberta (Fuller and Keith 1980) and Isle Royale Island in Michigan (Peterson 1977).

This difference in the breeding season and denning between wolves of temperate and tropical regions is due to the climatic conditions. At Nannaj, the weather during summer and the following monsoon is unfavourable for the wolves so they avoid breeding during these seasons.

The unfavourable conditions during summer such as less availability of food, water and high temperature could be deleterious to the pups. Similarly seepage during monsoon may lead to collapse of the den. Moreover, if the Nannaj wolves breed during summer as do the North American wolves and the wolves in Europe, the denning period will extend into the monsoon which may not be favourable to pups, although other proximate factors are favourable to the wolves during summer and the monsoon, because the prey species (Blackbuck) and the livestock congregate in larger flocks after it starts raining than during winter when they are more or less dispersed. Similarly, hares namely the Blacknaped hare *Lepus nigricollis nigricollis* are also common during monsoon. They feed on the fresh tender grass, which

comes up in the small ditches accumulating water for a short span. On a night's drive in July 1994, I counted 50 hares feeding on the fresh grass growth in these patches.

During both the breeding years, the study pack produced single litter, as seen elsewhere (e.g., Van Ballenberghe and Mech 1975; Haber 1977; Peterson 1977). Multiple litters are rare due to suppression of mating activity in subordinate members (Fox 1971; Schenkel 1947; Sullivan 1978, 1979; Rabb et al. 1967; Mech 1970; Haber 1977; Packard and Mech 1980; Zimen 1975), strong mate preferences and delayed sexual maturity (Packard and Mech 1980; Fox 1971; Rabb *et al.* 1967; Mech 1970). Because of these above mentioned within pack mechanisms, only one litter is born to a pack each year mostly by the dominant wolves of the pack. This behavioural mechanism influences strongly the population regulation of wolves.

Based on the literature available, Peterson (1977) predicted that natural selection would favour wolves that interfere with mating attempts of low-ranking (subordinate) pack members because producing several litters by a pack could reduce the chances of pup survival. On the contrary, if abundant food is available and mortality rate is also high, it is possible that multiple pregnancies could enhance pack survival (Carbyn 1980).

The wolves are well adapted to all kinds of biotic pressures. Nonetheless, they are sensitive to disturbance around the dens. In India, they are living around highly populated villages and even around towns. For instance, one male child of about

three years, was attacked and lifted by a wolf from the outskirts of Pratapgarh town in Uttar Pradesh on the night of 6/7 August 1996. This clearly shows their great adaptability to live around human beings. Moreover, if not persecuted they have a high potential to colonize and establish themselves, as has been proved by reintroduction of wolves to the Yellowstone National Park in 1995 and their subsequent colonizing the area from where they were exterminated in 1930's

CHAPTER TEN

CONSERVATION AND MANAGEMENT

Conservation of wolf in India is a very controversial issue. All over its distribution, the wild prey of the wolf has largely been decimated, so the wolf depends on livestock. Unlike its temperate cousin, the wolf in India is mainly found in scrubland, grassland and marginal agricultural areas. These areas are intensively used by human beings for livestock grazing, hence the wolf comes in direct conflict with man. There are very few sanctuaries (e.g. Velavador National Park, Jhala (1991); Rollapadu Wildlife Sanctuary, (Manakadan and Rahmani 1989); Melekote Wolf Sanctuary, Shahi (1982); Mahuadhar Wolf Sanctuary in Bihar) where the wolf survives.

During the last 15 years, some sanctuaries were established for the protection of Great Indian Bustard (Rahmani and Manakadan 1988), in marginal agriculture areas. With the establishment of these sanctuaries, good protection was given to all wildlife, resulting in the increase of Blackbuck populations. Wolves also increased in some areas, or at least they became more visible due to decrease in harassment. Wolf prey on Blackbuck and livestock, and Blackbuck feed on natural vegetation and crop. Farmers want the wolves to increase so they can decrease Blackbuck numbers but the shepherds want wolves to go as they kill livestock.

Crop-raiding behaviour of Blackbuck was investigated during this study to provide the basic information to the Forest Department for working out the compensation scheme for farmers against crop damage.

Under various conservation schemes, protected plots were developed by the Forest Department of Maharashtra state. The plots are dotted all over the Bustard Sanctuary, and many are outside also. These plots act as refuge to wildlife for food, shelter and breeding. Successful breeding of wolf was seen in two of such plots. The land which earlier was used as 'commons' for grazing was taken for these plots. Hence, the graziers suffer from two accounts: their common grazing land is taken over and their livestock is attacked by predators. In the democratic set up of India, no conservation movement can succeed unless the local people support it. The most important issue to be considered for wolf conservation is the payment of adequate compensation by the Government (Fritts 1982, Sawarkar 1986) for livestock destruction. Currently in India payments are made for Tiger and Lion kills alone. In Nannaj and elsewhere, the people are poor (average annual income is between Rs. 9000-10000) with small holdings and every loss of livestock is substantial. In order to prevent reprisal by shepherds against wolves, the Wildlife Wing of the Forest Department should pay suitable compensation to shepherds.

As the wolves at Nannaj depend mostly on wild Blackbuck for food during the non-breeding period, increasing the number of Blackbuck should decrease livestock depredation. However, it is not so simple. Firstly, livestock is easy to kill so if given opportunity, wolves go for easy kill. Secondly, crop damage by Blackbuck is a growing problem in Nannaj (and elsewhere in the Sanctuary), so any increase in the number of antelopes will be resisted by farmers. Farmers already illegally use snares to catch Blackbuck (Fig. 7.3). In few instances, wolves were caught in leg traps in Mohol and clubbed to death by irate villagers.

Habitat of the wolf is still abundant but continuously being disturbed by quarrying and industrialization around the Sanctuary. A spinning mill called Sharad Spinning Mill and an Oil mill have come up during the study period at Vadala and Karamba in the G.I.B. Sanctuary. Whereas setting up of another spinning industry (Gokak Spinning Mill of Tata Group) with a very large industrial setup in the Sanctuary was stopped because of a very strong protest by the State Forest and Wildlife Departments and the Bombay Natural History Society. These industries have direct disturbance on all the endangered animals viz., Blackbuck, Great Indian Bustard and the Wolf that are seen just around the campus of the Spinning mill. The movement of these animals is hindered by the workers at these industries. Several times Blackbuck die by hitting the forked bark, fencing the industrial premises.

For effective management of wolf in the area I recommend that there should not be any kind of disturbance upto a minimum distance of two kilometer from the core areas (protected plots) of the sanctuary.

Since the Sanctuary has an unmanageable area of 8,496 km^2 covering villages, towns, cities and several settlements, the boundaries as well as the area of the Sanctuary should be properly defined in order to reinforce the directives/legislation of the Wildlife (Protection) Act, 1972. One of the serious lapses in the Act is the continuous digging of the habitat of the Sanctuary due to quarrying which is detrimental to all the endangered large mammals of the Sanctuary. This is possible only if the highly populated areas falling in the Sanctuary be removed from it so it could become compact from management point of view. The Sanctuary area is densely populated with 101.29 people/sq km.

Fig. 10.4 Habitat Destruction due to quarrying around the Sanctuary

Stray dogs were observed hunting fawns (n=43) in the Sanctuary especially in summer (Fig. 10.1). They become a direct source of competition for food with the wolves during this period when Blackbuck is highly dispersed. Another threat to wolves from the dogs is the spread of diseases like rabies or any skin disease. These dogs should be killed by the forest guards.

At least for the trial sake, Reinforced Concrete Cement (R.C.C.) pipes should be implanted in the ground in plantation plots which could attract wolves for denning (Fig. 10.2). An R.C.C. pipe was regularly used by the wolves as a den during this study (see Breeding Biology). The wolves may take time till they become used to the presence of such pipes. The pipes should be placed in secluded areas and not in the open.

During the denning period of wolves (December to February) which is crucial for them (till the pups are restricted to dens), the sanctuary watchmen should guard active dens from a distance of 200-300 m against herders. Human travel routes and quarrying should be banned within a radius of 2 to 2.5 km around the den for the above mentioned period. The herders fumigate and block the dens during this critical period when pups are developing. The Sanctuary is a very good source of dispersal of wolf population to other potential areas since they are breeding successfully every year in this small relatively less disturbed area.

Shrubland patches present between adjacent plots of the Sanctuary should not be removed or thinned. It is recommended to maintain them at an optimal level so they

Fig 10.1 A stray dog feeding on Blackbuck fawn

Fig 10.2 An R.C.C. pipe placed in an open area by the sanctuary managers

would not affect wolf as well as bustards. The wolves and pups require 20-30% cover at their rendezvous sites (see habitat preference and use).

Malshiras, Sangola, North Solapur and Akkalkot are the best areas for long term survival of the wolf because of availability of prey and denning sites. Among these areas, Malshiras and Sangola have steep hills along their adjoining districts and have massive rock boulders. The soil under these boulders is loamy with soft texture which the wolves excavate easily for making dens. According to local people, they are using the same dens every year. The livestock population in each of these ranges is more than 20,000, which provides regular food.

The wolf is a highly endangered species, protected under the Wildlife (Protection) Act, 1972 but till now, not much has been done for its protection, mainly because of its reputation as livestock destroyer, and in some areas child-lifter. Fortunately, in Solapur district, no case of child lifting has been reported as far as I know but its so-called sheep and goat depredation makes it an unpopular animal. During the survey, all people interviewed about wolves responded with negative attitude towards its conservation.

About 42 children were reported to be killed and 22 were attacked and injured by wolves during 1996 in three districts namely Pratapgarh, Sultanpur and Jaunpur of Uttar Pradesh (a state in north India). I visited these areas during September-October 1996 for more than a week to investigate the cause of the problem. I was not able to find any direct evidence of wolves killing children. However, by examining the injuries and wounds on some children who survived their attacks, the pattern of bites was of a

wolf or possibly wolf hybrid. Based on the reports of few people in Jaunpur area, the possibility of existence of wolf hybrids in these areas, also cannot be ruled out.

78% of the victims (n=42) were of the age group 1-4 years and 64% of the victims which were attacked and dropped (n=22) off by wolves were 4-16 years old. All but four houses where these incidents occurred were located on the outskirts of the villages. The killings were done most probably by a single wolf or maximum by two as revealed by the measurements of tracks. Except for one child, all the incidents occurred either late in the evening or at night when people are busy in domestic chores or sleeping. Most of the killings were along Bakulahi and Sai rivers which pass through Pratapgarh and Jaunpur districts.

The Sai river courses about 72 km in Pratapgarh and 32 km in Jaunpur before joining another river known as Gomati. The strip of land on either side of this riverine course dotted by bushes and Acacia trees, is an ideal wolf habitat which probably harbour few wolves of the remnant population in the state. In addition, wolves are using certain patches of the "open" and "semi-open" pockets in the crop fields.

Again during February-March 1997, the wolves were reported to kill five more children and seriously wounded five others in Rae Bareli district which is adjacent to Pratapgarh. Most of these casualties were the direct result of negligence of people to protect their children.

The district administration had employed local trappers known as *Banjaras* and *Kanjars* to trap the killer wolves. Ten wolves and many jackals and foxes were killed by the Police and the Forest guards during the operation (Fig. 10.3).

No wild prey is left in these areas due to excessive hunting and there is hardly any wolf habitat left for wolves due to intensive agriculture. Moreover, these areas are densely populated. The wolves are living very close to humans in these areas and such incidents can happen anytime in future too.

The reports of wolves attacking man are extremely rare (Mech 1970) and wherever any such event has ever occurred, it has been exaggerated galore. It appears that one or two wolves had lost their fear of humans and regarded the children as prey. Carbyn (1989) has reported 14 Coyote attacks on children in the Canadian Rocky Mountains (Banff and Jasper National Parks), western Alberta, and Yellowstone National Park in northwestern Wyoming. It is the first time in the world that a large number of children fell prey to wolves (or wolf hybrids) in India. Earlier Shahi (1982) has documented killing of children by wolves in Hazaribagh area of Bihar in India.

There has been more public animosity towards wolves in the entire country after these child killing incidents of Uttar Pradesh during 1996-97.

Despite continuous persecution by human beings, the wolf has resilience to survive, chiefly due to its adaptability and intelligence. The wolf, like the Great Indian Bustard and Blackbuck, has responded positively to conservation measures in the form of plantation and grassland plots developed under various schemes. However, this has

Fig 10.3 A juvenile wolf killed in Pratapgarh district (Uttar Pradesh) in 1996

not reduced human-wolf conflict, the ultimate victim of which is invariably the wolf. It is a very complex issue, without an easy solution. Nevertheless, the following steps are recommended which might minimize human- wolf conflict and increase chances of wolf survival:

(1) Adequate livestock compensation for wolf depredations.

(2) Translocation of Blackbuck from locally-abundant areas to other suitable unoccupied habitats.

(3) Some measure of compensation for crop-damage by Blackbuck should be worked out to reduce Human-Blackbuck conflict.

(4) Special protection to denning sites and core areas which are generally occupied by wolves. (5) Development of large grassland and plantation plots, especially around denning sites used regularly by wolves.

(6) Intensive studies on the movement, dispersal, habitat requirements and general ecology of the wolf in Maharashtra, using modern techniques of radio-telemetry, marking etc.

(7) Regular wolf census in Maharashtra, atleast once in two years.

(8) The patches of grasslands as well as scrublands between the protected plots of the Sanctuary should be taken over by the State Forest/Wildlife Department.

(9) The stray dogs seen in the Sanctuary should be eliminated.

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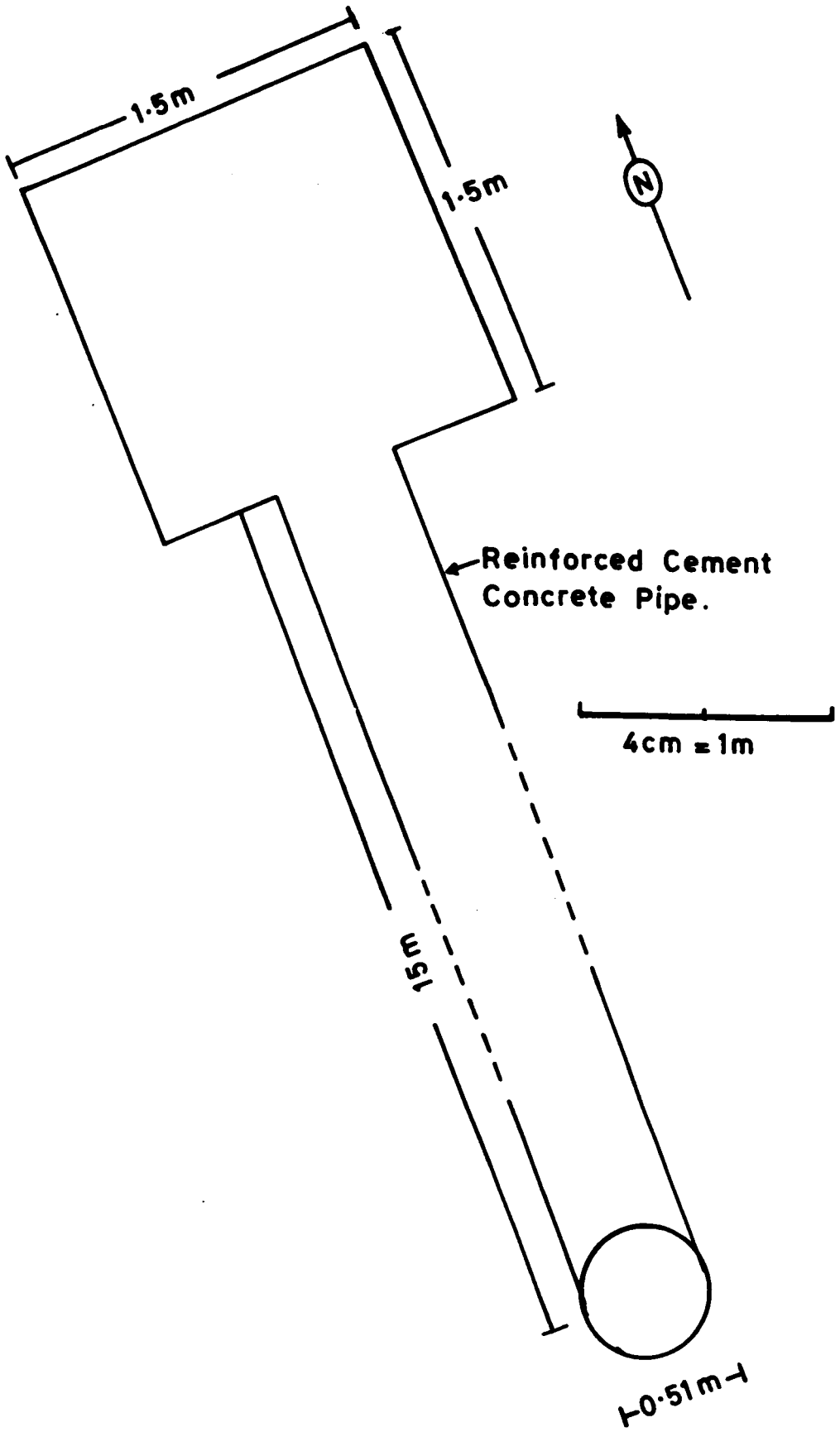
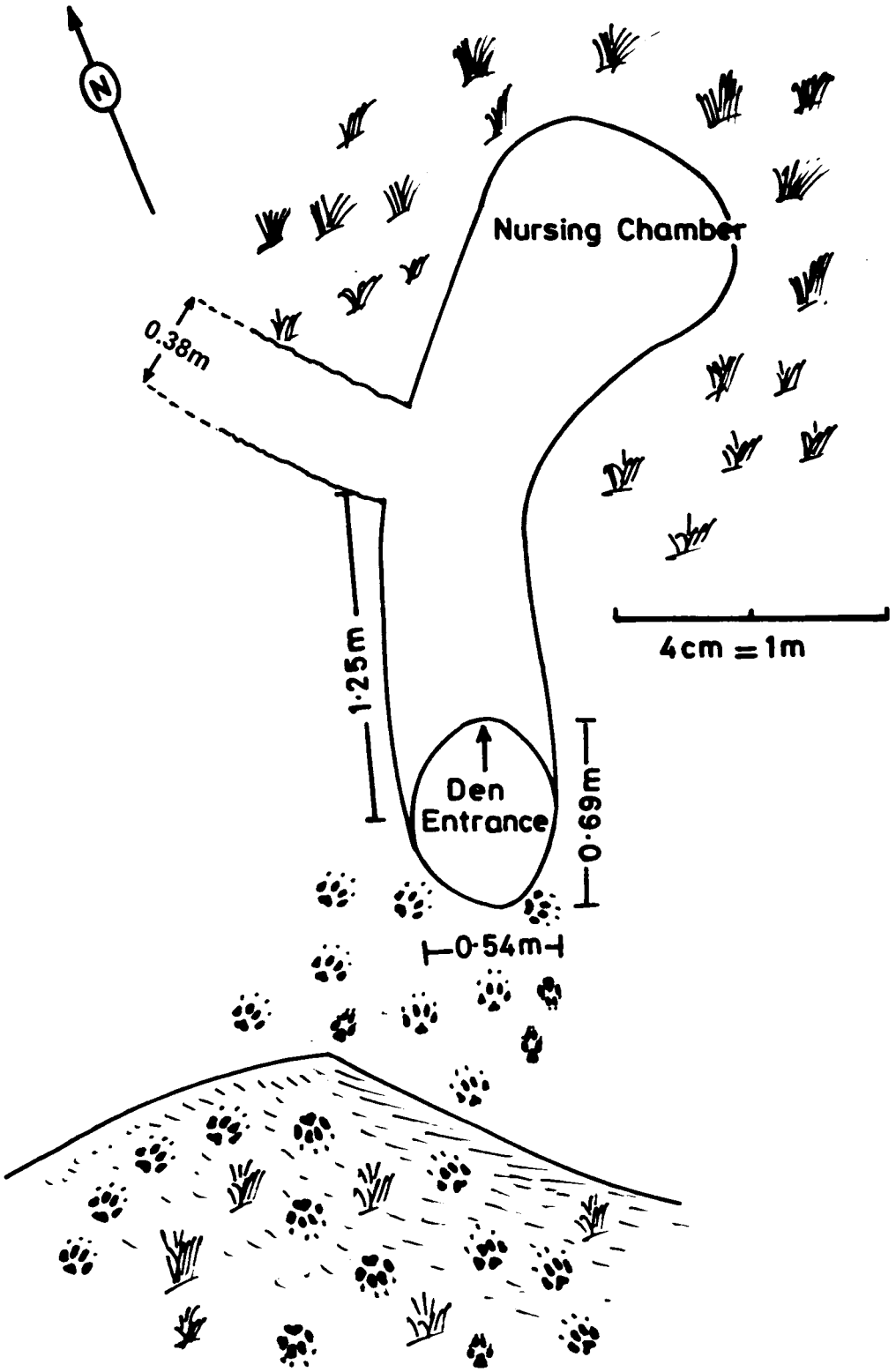
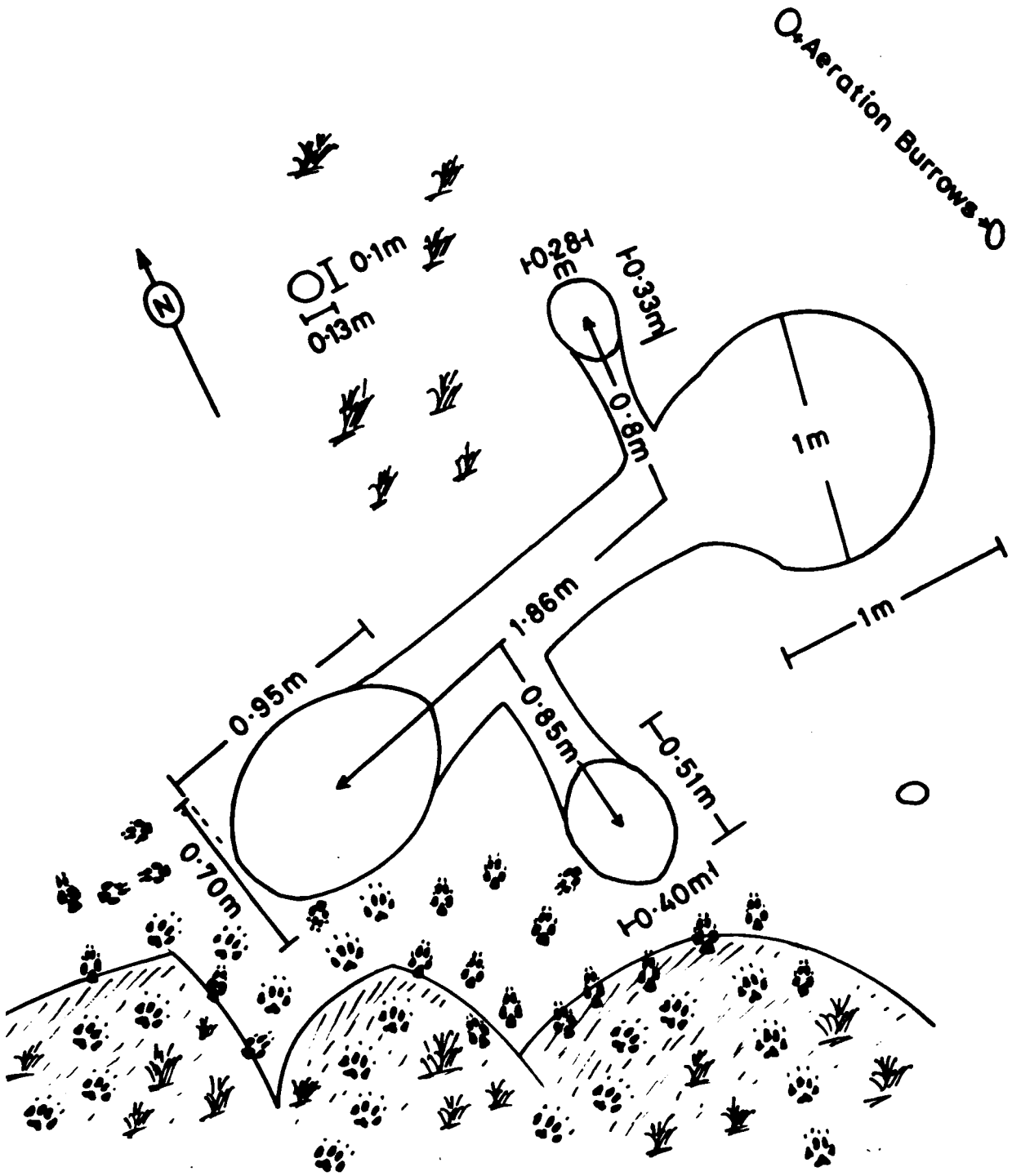
Appendix-A Sketch of interior of den #1



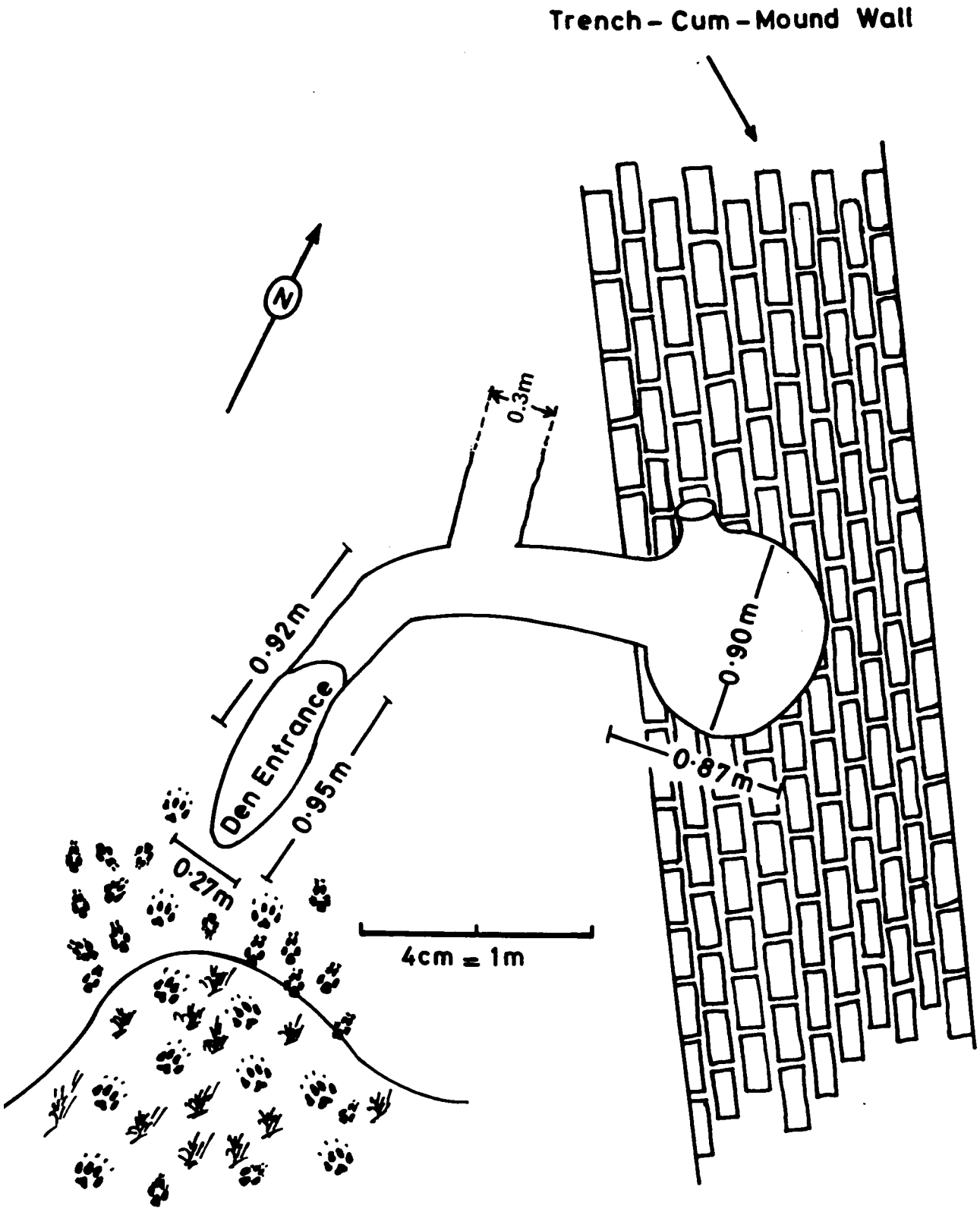
Appendix-B Sketch of interior of den #2



Appendix-C Sketch of interior of den #3



Appendix-D Sketch of interior of den #4



APPENDIX -E Checklist of birds of the Great Indian Bustard Sanctuary, Nannaj, Solapur

Common name	Scientific name	Habitat			
		Gr	Pt	Pl	Hb
Little Grebe	*Podiceps ruficollis*	+			
Pond Heron	*Ardeola grayii*		+		
Cattle Egret	*Bubulcus ibis*	+			
Little Egret	*Egretta garzetta*		+		
Painted Stork	*Mycteria leucocephala*		+		
Whitenecked Stork	*Ciconia episcopus*	+	+		
White Ibis	*Threskiomis aethiopica*	+	+		
Black Ibis	*Pseudibis papillosa*	+	+		
Spotbilled Duck	*Anas poecilorhyncha*		+		
Blackshouldered Kite	*Elanus caeruleus*	+		+	
Pariak Kite	*Milvus migrans*	+		+	
Shikra	*Accipiter badius*	+		+	+
White-eyed Buzzard-eagle	*Butastur teesa*	+		+	
Hen-Harrier	*Circus cyaneus*	+			
Pale Harrier	*Circus macrourus*	+			
Montagu's Harrier	*Circus pygargus*	+			
Bonelli's Eagle	*Hieraaetus fasciatus*	+		+	
Short-toed Eagle	*Circaetus gallicus*	+			
Redheaded Merlin	*Falco chicquera*	+			
Kestrel	*Falco tinnunculus*	+			
Painted Francolin	*Francolinus pictus*	+		+	
Grey Francolin	*Francolinus pondicerianus*	+		+	+
Rain Quail	*Coturnix coromandelica*	+		+	
Rock bush Quail	*Perdicula argoondah*	+		+	+
Peafowl	*Pavo cristatus*			+	+
Great Indian Bustard	*Ardeotis nigriceps*	+			
Lesser Florican*	*Sypheotides indica*			+	
Blackwinged Stilt	*Himantopus himantopus*		+		
Indian Courser	*Cursorius coromandelicus*	+			
Redwattled Lapwing	*Vanellus malabaricus*	+	+		
Little Ringed Plover	*Charadrius dubius*		+		
Common Sandpiper	*Tringa hypoleucos*		+		
Indian River Tern	*Sterna aurantia*		+		
Indian Sandgrouse	*Pterocles exustus*	+			
Blue Rock Pigeon	*Columba livia*	+			+
Indian Ring dove	*Streptopelia decaocta*	+		+	+
Red Turtle Dove	*Streptopelia tranquebarica*	+		+	+
Little Brown Dove	*Streptopelia senegalensis*	+		+	+
Roseringed Dove	*Psittacula krameri*			+	+
Blossomheaded Parakeet	*Psittacula cyanocephala*			+	+

Peid Crested Cuckoo	*Clamator jacobinus*	+		+	+
Brainfever Bird	*Cuculus varius*			+	+
Koel	*Eudynamys scolopacea*			+	+
Crow-pheasant	*Centropus sinensis*		+	+	
Great Horned Owl	*Bubo bubo*	+		+	
Spotted Owlet	*Athene brama*			+	+
Shorteared Owl	*Asio flammeus*	+		+	
Common Indian Nightjar	*Caprimulgus asiaticus*			+	+
Pied Kingfisher	*Ceryle rudis*		+		
Whitebreasted Kingfisher	*Halcyon smymensis*	+		+	
Green Bee-eater	*Merops orientalis*	+		+	+
Kashmir Roller	*Coracias garrulus*	+			
Indian Roller	*Coracias benghalensis*	+		+	+
Hoopoe	*Upupa epops*	+		+	+
Common Grey Hornbill	*Tockus birostris*			+	+
Coppersmith	*Megalaima haemacephala*		+	+	
Yellowfronted Pied Woodpecker	*Picoides mahrattensis*			+	
Redwinged Bush Lark	*Mirafra erythroptera*	+		+	
Ashycrowned Finch-Lark	*Eremopterix grisea*	+		+	+
Rufoustailed Finch-Lark	*Ammomanes phoenicurus*	+		+	+
Short-toed Lark	*Calandrella cinerea*	+			
Sykes's Crested Lark	*Galerida deva*	+			+
Eastern Skylark	*Alauda gulgula*	+			
Redrumped Swallow	*Hirundo smithii*	+	+		+
Grey Shrike	*Lanius excubitor*	+		+	+
Baybacked Shrike	*Lanius vittatus*			+	+
Rufousbacked Shrike	*Lanius schach*			+	+
Golden Oriole	*Oriolus oriolus*			+	
Black Drongo	*Dicrurus adsimilis*	+		+	+
Rosy Pastor	*Sturnus roseus*	+			+
Brahminy Myna	*Sturnus pagodarum*	+		+	+
Common Myna	*Acridotheres tristis*			+	+
House Crow	*Corvus splendens*	+		+	+
Jungle Crow	*Corvus macrorhynchos*	+		+	+
Large Cuckoo-Shrike	*Coracina novaehollandiae*		+	+	
Common Wood Shrike	*Tephrodornis virgatus*			+	
Small Minivet	*Pericrocotus cinnamomeus*		+	+	
Common Iora	*Aegithina tiphia*			+	
Redvented Bulbul	*Pycnonotus cafer*	+		+	+
Common Babbler	*Turdoides caudatus*	+		+	
Large Grey Babbler	*Turdoides malcolmi*	+		+	+
Streaked fantail Warbler	*Cisticola juncidis*	+			
Plain Wren Warbler	*Prinia subflava*	+		+	+
Ashy Wren Warbler	*Prinia socialis*	+		+	+
Tailor Bird	*Orthotomus sutorius*			+	+
Lesser Whitethroat	*Sylvia curruca*	+		+	+
Magpie-Robin	*Copsychus saularis*			+	
Pied Bush Chat	*Saxicola caprata*	+		+	
Isabelline Wheatear	*Oenanthe isabellina*	+			
Desert Wheatear	*Oenanthe deserti*	+			

Redstart	*Phoenicurus phoenicurus*				+
Indian Robin	*Saxicoloides fulicata*		+	+	
Great Tit	*Parus major*			+	+
Pipit (?)	*Anthus* sp.	+		+	
Tawny Pipit	*Anthus campestris*	+			+
Yellowheaded Wagtail	*Motacilla citreola*	+	+		+
Grey Wagtail	*Motacilla cinerea*		+		+
Pied Wagtail	*Motacilla alba*		+		+
Large Pied Wagtail	*Motacilla maderaspatensis*	+		+	
Purple Sunbird	*Nectarinia asiatica*			+	+
Purplerumped Sunbird	*Nectarinia zeylonica*		+	+	
House Sparrow	*Passer domesticus*		+	+	
Yellowthroated Sparrow	*Petronia xanthocollis*			+	
Baya	*Ploceus philippines*	+		+	
Whitethroated Munia	*Lonchura malabarica*	+		+	+
Spotted Munia	*Lonchura punctulata*	+			
Redheaded Bunting	*Emberiza bruniceps*	+			
Greynecked Bunting	*Emberiza buchanani*		+		

Gr = Grassland
Pt = Percolation tank
Pl = Plantation
Hb = Human Habitation
* Single sighting record

APPENDIX-F Checklist of mammals and reptiles of the Great Indian Bustard Sanctuary, Nannaj

Mammals

Common name	Scientific name
Jungle cat	*Felis chaus*
Common mongoose	*Herpestes edwardsi*
Indian Grey Wolf	*Canis lupus pallipes*
Golden jackal	*Canis aureus*
Indian fox	*Vulpes bengalensis*
Five-stripped squirrel	*Funambulus pennanti*
Blacknaped hare	*Lepus nigricollis nigricollis*
Blackbuck	*Antilope cervicapra*

Reptiles

a) Lacertils

Common garden lizard	*Calotes versicolor*
Fan-throated lizard	*Sitana ponticeriana*
Common or Brahminy skink	*Mabuya carinata*
Little skink	*Mabuya macularia*
Common Indian monitor	*Varanus bengalensis*

b) Serpents

Common worm snake	*Typhlina bramina*
John's earth boa	*Eryx johni*
Trinket snake	*Elaphe helena*
Common rat snake	*Ptyas mucosus*
Catsnake	*Boiga trigonata*
Common Indian krait	*Bungarus caeruleus*
Indian cobra	*Naja naja naja*
Russell's viper	*Vipera russelli*
Saw-scaled viper	*Echis carinatus*